Core (COR) Package
Users' Guide

The MELCOR Core (COR) package calculates the thermal response of the core and lower plenum internal structures, including the portion of the lower head directly below the core. The package also models the relocation of core and lower plenum structural materials during melting, slumping, and debris formation, including failure of the reactor vessel and ejection of debris into the reactor cavity. Energy transfer to and from the Control Volume Hydrodynamics (CVH) package and the Heat Structure (HS) package is calculated. This Users' Guide provides basic information needed to run the COR package with the rest of MELCOR, including a short discussion of the nodalization scheme and calculational framework of the package and a detailed explanation of the user input and package output for MELGEN, MELCOR, and HISPLTM. Required and optional input, sensitivity coefficients, control function arguments, plot variables, and error messages are all covered.

More detailed information on the physics models and numerical solution schemes employed in the COR package can be found in the COR Package Reference Manual.

Contents

1. Introduction

The MELCOR COR package calculates the thermal response of the core and lower plenum structures, including the portion of the lower head directly beneath the core, and models the relocation of core materials during melting, slumping, and debris formation. It also calculates a simplified mechanical response of the lower head to the differential pressure between the lower plenum inside the vessel and the reactor cavity outside the vessel. An alternative modeling of lower plenum and lower head phenomena is optionally available through the separate Bottom Head (BH) Package. Multiple structures are modeled as separate components within a single core cell. Intact components include fuel pellets, cladding, canister boxes, and other structure (e.g., control rods). Canister boxes are only present in Boiling Water Reactors (BWRs). Particulate debris is also modeled as a possible component within a core cell. Each of these components may be composed of several materials (e.g., Zircaloy and ZrO_2 in the cladding) which are maintained in thermal equilibrium. This is discussed in more detail in Section 1.1.

All important heat transfer processes are modeled for each cell component. Thermal radiation among the various components within a cell and between cells in both the axial and radial directions is included, as well as radiation to boundary structures [e.g., the core shroud or upper plenum, which are modeled by the Heat Structures (HS) package] and to a liquid pool. Melting of boundary steel structures, with addition of the molten steel to the core debris, may be modeled using appropriate input to the HS package. Gap radiation/conduction between fuel and cladding and axial conduction in each of the components is modeled. Convection to the fluid in adjacent control volumes is modeled for a wide range of fluid conditions and structure surface temperatures, including nucleate and transition film boiling. Oxidation of Zircaloy and steel is modeled for both the limiting cases of solid-state diffusion of oxygen through the oxide layer and gaseous diffusion of steam or oxygen through the gas mixture. The reaction of B_4C with steam is also modeled. Although, the default B_4C oxidation model produces satisfactory results in highly oxidizing atmospheres, it is recommended that the advanced B_4C reaction model be invoked (through adjustment of sensitivity coefficient 1005) if significant hydrogen concentrations (reducing environment) are expected.

The core degradation model treats eutectic reactions that lead to liquefaction below normal melting points, dissolution reactions that lead to significant fuel relocation below the UO_2 melting temperature, "candling" of molten core materials (i.e., downward flow and refreezing), and the formation and relocation of particulate debris. Various geometric variables (e.g., cell surface areas and volumes) are updated for changing core geometry.

Changes in core flow resistance resulting from relocation of core materials may be modeled, but the connection to the hydrodynamic packages (CVH and FL), is *not* automatic. Input on FLnnnBk records is required to specify which core cells are associated with each flow path involving the core. Because only CVH and FL model the flow of water

and gases, the effects of blockages on circulation can be modeled only to the extent that the CVH/FL nodalization can resolve that circulation.

The remainder of this section briefly describes the nodalization scheme and the calculation framework used in the COR package. More comprehensive information on these topics, as well as on the specific phenomenological models used, is given in the COR Package Reference Manual.

1.1 Nodalization Scheme

The core and lower plenum regions of the reactor vessel are divided into concentric radial rings and axial levels; the numbers of rings and levels are input by the user. A particular radial ring and a particular axial level define a core cell, whose cell number is specified by a three-digit number; the first digit represents the radial ring number and the last two digits represent the axial level number. For example, cell 307 designates the third radial ring and the seventh axial level. Radial rings are numbered from the center out and axial levels are numbered from the bottom up.

The scheme described above applies only to structural materials in the core and lower plenum, and is independent of the control volume (CVH) nodalization for the reactor vessel. Each core cell interfaces with a primary, or channel, fluid volume. For BWRs, a secondary, or bypass, fluid volume is specified for cells in the core to represent the interstitial volume between fuel assemblies. Typically, a single CVH control volume will interface with many core or lower plenum cells.

Each core cell may contain one or more components. Seven intact components are modeled:

(1) fuel pellets,

(2) cladding, and

(3) BWR canister walls, split into two parts: one part not adjacent to the control blade and another part that is,

(4) "supporting structure,"

(5) "nonsupporting structure," and

(6) "other structure."

Because of the effects of radiation to the control blade, the two canister parts may have significantly different temperatures.

A core cell may also contain particulate debris ("rubble") resulting from the collapse of fuel rods and other core components. In a BWR, such debris may reside either inside or outside the channel box, in the channel or bypass region, respectively. Unlike previous versions, MELCOR 1.8.5 distinguishes particulate debris in the channel from that in the bypass, using separate components for each. The distinction exists only for a BWR, and only for core cells that have distinct channel and bypass regions. Even then, most of the distinction is lost when the channel box fails, although both types of particulate debris must continue to be tracked because they typically occupy space in different CVH control volumes.

Conglomerate debris, i.e., core material that has melted and resolidified, is modeled as an integral part of the component onto which it has frozen, which may be any one of the above except fuel pellets. Heat transfer and oxidation processes are modeled separately for each component.

The following table identifies each component by its component number and component identifier, which are often used in the COR package documentation.

1	FU	intact fuel component
2	CL	intact cladding component
3	CN	intact canister component (portion not adjacent to the control blade)
4	CB	intact canister component (portion adjacent to the control blade)
5	OS	"other structure" component
6	PD	particulate debris component (portion in the channel for a BWR)
7	SS	"supporting structure" component
8	NS	"nonsupporting structure" component
9	PB	particulate debris component in the bypass (for a BWR)

The primary difference between the "supporting" and "nonsupporting structure" components is the ability to support other core components (core support structures) or not (control rods or blades). NS is intended to represent things like control rods/blades in Pressurized Water Reactors (PWRs) and BWRs, "stiffeners" in Phebus experiments, and other similar objects that cannot support anything except themselves. All core elements that have the capability of supporting other types of core components are intended to be modeled using the SS component. These include core plates, and CRGTs in BWRs. Modeling options involving SS and NS are discussed in Section 1.3.

The option of using OS has been retained from older versions of MELCOR, but requires that a flag be set on the COR00006 input record. It may not be used in combination with either of the "supporting" or "nonsupporting" structure components. This allows old decks to be run, but the practice is not recommended. In general, the capabilities of models involving the OS component have not been upgraded beyond those in MELCOR 1.8.4.

Each component may be composed of one or more materials. Eight materials are modeled in the COR package:

(1) UO_2,

(2) Zircaloy,

(3) steel,

(4) ZrO_2 ,

(5) steel oxide,

(6) control rod poison, which may be either boron carbide (B_4C) or silver-indium-cadmium alloy (Ag-In-Cd),

(7) Inconel, and

(8) electric heating element material (defined by the user).

The last of these is intended for use in analysis of electrically heated experiments. If it is present in a core cell, subroutine ELHEAT will be called to calculate the associated heating power in that cell. The distributed version is only a stub that will terminate the calculation if it is called. The user must therefore modify this subroutine as appropriate to the particular experiment under consideration, and link the modified version.

These materials melt, relocate, and freeze separately and independently unless the core materials interactions model has been activated, in which case they form a mixture that melts, relocates, and freezes coherently. Steel and steel oxide are each considered a single material within the COR package, but the user must specify (in Material Properties package input) the fractions of iron, nickel, and chromium in the steel so that oxidation can be properly treated and the right amounts of each species can be transmitted to the Cavity (CAV) package during debris ejection. The melting and candling of materials results in the possibility of any or all materials being found in a given component.

A lumped parameter approach is used for each component within a cell; therefore, each component is represented by a single equilibrium temperature. All thermal calculations are done using internal energies of the materials, and the mass and internal energy of each material in each component are tracked separately to conserve total mass and energy to within machine roundoff accuracy.

Several geometric variables are used to further describe the cells. For each structural component a surface area is defined for convection and oxidation calculations; the canister components have defined surface areas for each side to communicate separately with the channel and bypass control volumes. The effects of conglomerate debris on component surface areas are factored into the oxidation calculations, and for oxidation of debris,

separate Zircaloy and steel surface areas are used. Equivalent diameters for each component are also specified for use in various heat transfer correlations. Cell boundary areas for inter-cell radiation (both axially and radially) are defined. Volumes of components and the "empty" fluid space are tracked for core slumping and flow blockage calculations.

For each radial ring the user can define up to three representative penetrations (e.g., instrumentation tubes or guide tubes) in the lower head, specifying their mass and surface area. The lower head is modeled as a hemispherical shell of user-specified thickness and composition. The user must specify the thickness and composition of an arbitrary number of radial nodes (not to exceed 24) beginning from the outer surface of the hemisphere and progressing inward. In addition to stainless steel, which is included in the COR package data base, the user may specify up to six materials in a composite lower head. Hence, with appropriate Materials Properties (MP) package input the user may model insulation, carbon steel and a stainless steel liner if desired. The outer node (surface) communicates with the CVH fluid in the reactor cavity, and downward-facing boiling heat transfer to a flooded cavity is modeled. The inner node (surface) communicates thermally with both the penetrations and the debris. Heat transfer from the debris to the lower head and its penetrations is modeled parametrically. A one-dimensional solution is used to determine the temperature profile through the lower head. The temperature profile and the loading of the vessel can be used by the lower-head mechanical model to predict creep-rupture failure of the lower head using the Larson-Miller parameter and a life-fraction rule.

1.2 Calculation Framework

The COR package uses an explicit numerical scheme for advancing the thermal state of the core through time. To mitigate numerical instabilities, a subcycling capability has been developed to allow the COR package to take multiple time steps across a single system cycle. All energy generation and heat transfer rates are evaluated at the beginning of a COR package subcycle based on current temperatures, geometric conditions, and an estimate of the local fluid conditions (calculated by the COR package dT/dz model to reflect the temperature variation of a control volume containing many individual core cells). The net energy gain (or loss) across the subcycle is determined for each component by multiplying these rates by the COR package time step. The temperature change for any component with total mass greater than a user-specified minimum is limited to a user-input maximum; if the calculated temperature change is greater than this limit, the core time step is reduced accordingly. If the energy input to any fluid volume changes from previous values in such a way as to possibly result in numeric instability between the COR and CVH packages, the system time step may be immediately cut or a reduction may be requested for the next system cycle.

At the end of the COR package time step, after the thermal state of the core has been updated, relocation of core materials and debris formation are calculated by the core degradation models. First, molten intact materials are moved from intact components to the conglomerate debris associated with the components. Then, if the materials

interactions model has been activated, eutectic reactions are calculated between various intact solid materials within a component if the component temperature exceeds the eutectic points, and dissolution reactions between certain intact solid materials and molten eutectic mixtures are calculated (e.g., intact UO_2 fuel dissolved by Zircaloy-bearing mixtures); these materials are also added to the conglomerate debris. Molten materials are relocated downward by the candling model (provided there is no flow blockage) and radially by the spreading model if there is a significant difference in the liquid levels in adjacent core rings. Intact components are converted to debris if various debris formation criteria are met.

Relocation of particulate debris downwards and radially by gravitational settling is normally modeled at the end of a core subcycle by logical processes through consideration of volume, porosity, and support constraints. Rates are not explicitly considered; however, a limit on the maximum rate is imposed to force the relocation to go to zero for very small timesteps. However, if the user has activated the in-vessel falling debris quench model, then debris relocation immediately following the failure of the core support plate in each radial ring is calculated assuming that the debris falls at a constant velocity. Furthermore, during a short time interval following the failure of the core support plate, heat transfer from the falling debris to the pool of water in the lower plenum is calculated. This model can be used to simulate energetic fuel-coolant interactions that may occur and threaten the integrity of the reactor pressure vessel.

Whenever mass is relocated or debris formed, energies in the new or changed components are re-evaluated to maintain thermal equilibrium, and any relevant geometric variables are recalculated to reflect the change in geometry. Failure of the core plate (or any other structure modeled as SS or OS and providing support) is predicted based on models described in Section 1.3. Failure of the lower head is assumed to occur based on any of a number of criteria:

(1) the temperature of a lower head node or penetration reaches a critical temperature defined by the user,

(2) the differential pressure exceeds a user-specified maximum,

(3) the accumulated plastic strain exceeds the failure limit, which may be modified by the user, or

(4) the value of a user-specified logical control function is found to be true.

1.3 Support of Core Structures

Only the single one-size-fits-all "other structure" component, OS, was available in older versions of MELCOR to represent control rods, control blades, core plates, and CRGTs—in fact, to represent everything in an intact core *except* fuel rods and their cladding, and the

canister boxes in BWRs. In a sense, OS was forced to represent such a variety of things that it could represent none of them particularly well, a problem that was exacerbated by the fact that the input options associated with OS were rather primitive and inflexible. Although the OS component and models based on it have been retained for compatibility with older input decks, their use requires setting the model switch IOLDOS=1 on the COR00006 input record. The option to use OS will probably be eliminated in future versions of the code.

The preferred modeling approach in MELCOR 1.8.5 is to represent supporting structures (such as core support plates) and nonsupporting structures (such as control rods/blades) as *separate* components, SS and NS, respectively. The SS and NS components can represent only one type of structure in each core cell, but they may be used to represent quite different types of structures in different core cells. Neither can be used in conjunction with OS.

NS cannot support anything but itself. It may be supported from below like a BWR control blade, supported from above like a PWR control rod, or fixed in place like elements of certain experimental facilities (e.g., the stiffeners in Phebus). Local failure of NS is based on the remaining thickness of structural metal and on temperature. It will fail if the thickness of metal falls below a critical value or—regardless of the thickness of metal remaining—if the temperature exceeds a limiting value. The structural metal is taken as steel by default, but can be specified to be Zircaloy. The default failure temperature is the melting point of the structural metal. Both the critical thickness and the limiting temperature can be redefined if desired.

SS can support itself and other core components, with several choices available for the models to be applied in each core cell. The choice of models affects the treatment of support and loading, the failure criteria, and the consequences of failure. Structural modeling of SS in a core cell is tied to an input keyword. The options are

(1) PLATE, representing part of an edge-supported plate that can initially support fuel assemblies and particulate debris above it, and any inner sections of the same plate. On failure, SS modeled as PLATE is converted to particulate debris along with everything supported by it, including any unfailed inner rings of the same PLATE and anything supported by them.

(2) PLATEG, representing part of a grid-supported or eggcrate plate that can initially support fuel assemblies and particulate debris above it. On failure of SS modeled as PLATEG, only the capability to support particulate debris and intact components in cells above is removed. Thus, everything resting on that ring of the plate will fall, but the plate will remain in place until it melts. The picture corresponds to failure of the plate portion with survival of the grid, and closely resembles the modeling using OS in MELCOR 1.8.4.

(3) PLATEB, representing part of a BWR plate that can initially support only particulate debris, although its presence is required to transfer the weight of fuel assemblies and canisters to control rod guide tubes (CRGTs) below it. On failure of SS modeled as PLATEB, only the capability to support particulate debris in cells above is removed. Thus, intact fuel and canisters can continue to be supported by the CRGTs below, and the failed plate will remain in place until it melts.

(4) COLUMN, representing the CRGTs in a BWR that can initially support nothing but themselves and, through the mediation of PLATEB, fuel assemblies and canisters above the core plate. On failure, SS modeled as COLUMN is converted to particulate debris, along with anything supported by it including any unfailed upper sections of the same column and any other components whose weight is transferred to it by an element of PLATEB.

SS may be specified as failing when a critical temperature is exceeded or when a specified logical control function becomes true. It may also be specified as failing under load, by yielding, as a consequence of creep, or, where appropriate, by buckling. The stresses are calculated from the total load, based on simple mechanical models appropriate to the form assumed for the SS. More details may be found in the COR Package Reference Manual.

The specification of NS and SS models is very flexible. There are global defaults, which may be based on the core type, that may be overridden by optional user input. Modeling options may be redefined by axial level, by radial ring, or by individual core cell. The input records involved are COR000NS, CORZjjNS, CORRiiNS, and CORijjNS for NS, and COR000SS, CORZjjSS, CORRiiSS, and CORijjSS for SS. The records are processed in that order, and the modeling in each cell is based on the last relevant input encountered.

1.4 User Control of Core Oxidation and Material Relocation

In the oxidation of core components, there is competition among various surfaces for the available oxidizers (steam and/or oxygen). In addition to competition between surfaces within a single core cell, which is treated by internal models described in the Core Package Reference Manual, there is also competition among core cells that interface with the same CVH control volume for a share of the total oxidizer inventory of that control volume.

If one CVH control volume contains (parts of) several rings of the core, the available oxidizers are divided in proportion to the minimum open flow areas in each of those rings within the control volume. (The possibility of cross flows is not considered.) The internal calculation of areas may be used, or the user may choose to specify the flow splits using control functions as specified on the optional CORVOLxxx records. Minimum fractions may be imposed, using sensitivity coefficient array 1007, to avoid total steam starvation. If several core levels are contained in the ring, each is given access in turn to the total inventory of oxidizers remaining in that ring after oxidation is evaluated for cells that come earlier in the order. Cells are processed in the direction of assumed flow through the ring.

By default, this is currently based on the computed direction of flow at the exit plane of the core, but can be overridden by control functions specified on optional CORRii04 records.

Core materials can relocate by melting and candling. They can also fail mechanically and be converted to particulate debris ("rubble") which can then slump to lower parts of the core if there is space available. Materials interactions (formation of "eutectics") are frequently involved in these processes. MELCOR has a materials interactions model, activated by input on the COR00006 record, but users of version 1.8.3 reported problems with the model. Although some of these problems were resolved in later versions, we presently recommend that the model be used with great care, if at all. The most important effects of materials interactions can be captured using parametric models.

When materials that form core components melt, they are usually assumed to candle immediately. The exception is molten metal (Zr and stainless steel) held up behind oxide shells; parameters used in the holdup model are part of sensitivity coefficient array 1131. If the materials interactions model is not active, the dissolution of other materials in candling molten metals is modeled by "secondary transport" parameters input on the COR00007 record.

Note that molten metal may be associated with an intact component, either held up behind an oxide shell or as conglomerate that is prevented from candling by the absence of free volume in a lower cell.

When the remaining thickness of unoxidized metal in a component in a core cell is reduced below a minimum defined by input on record COR00008, the component is converted to particulate debris. Two exceptions are made for fuel rods. First, oxidized fuel rods are assumed not to fail until the temperature has risen to a value that, by default, approximates the eutectic temperature for the UO_2/ZrO_2 system, at which materials interactions would begin to liquify the solid structure. Second, fuel rods are assumed to fail unconditionally (regardless of other input) if the fuel temperature reaches a value that, by default, approximates the melting temperature of UO_2. The two threshold temperatures are defined by sensitivity coefficient array 1132.

Intact components are also converted to particulate debris if they lose support. A component in a core cell is supported by existence of the same component in the next lower cell (the next *higher* cell for NS supported from above). It may also be supported by unfailed SS or OS in the next lower cell. For representations using OS, all components may also be defined as "self supporting" by appropriate definition of support flags on CORZjj02 records.

Particulate debris (PD and/or PB) will slump, subject to constraints of available volume and support by SS or OS. In general, particulate debris cannot fill the entire volume that would be available to fluid in a core cell. The volume available to particulate debris in the channel and/or bypass of any cell is based on the parameters specified for the debris exclusion

model in that cell, as input on COR000DX, CORZjjDX, CORRiiDX, and/or CORijjDX records.

These parameters allow intact components to exclude particulate debris from a volume larger than their physical volume, specified as fractions of the associated total volume, either channel or bypass. (Of course, particulate debris will be excluded from the physical volume of the component in any case.)

The default values will prevent particulate debris from entering the channel region while intact fuel rods are present. In a BWR, they will also prevent it from entering the unbladed portion of the bypass region while there is intact CN, or the bladed portion of the bypass region while there is intact NS representing control blades. See Section 3.2.3 of the COR Package Reference Manual for more discussion of the model.

The porosity of a debris bed specified as PORDP on CORZjj01 input records is also considered. The "intact material porosity", PORIN, input on these records is not used in any way in MELCOR 1.8.5.

Support is determined by the specification of structural models for SS, or by support flags defined on CORZjj02 records for OS. Both SS and OS lose their ability to support particulate debris and other components when they fail. Several models are available for the loading and failure of SS; the choice is defined by input variables on COR000SS, CORZjjSS, CORRiiSS, and/or CORijjSS records. OS fails when it reaches a failure temperature defined on CORZjj04 records, or when a logical control function specified on a CORijj07 record becomes TRUE. (These inputs are not used for SS). When SS in a core cell fails, it may or may not be converted to particulate debris, depending on the specific option chosen for SS in that cell. The failure of OS does not result in its conversion to particulate debris, nor does it affect the ability of the OS to support itself. As a result, self-supporting OS (ISUP input as x1 on record CORZjj02) will remain in place until it melts.

1.5 Conversion of Older Decks for Use with MELCOR 1.8.5

Changes to COR package input are required to take advantage of many of the significant changes that have been made to core modeling in MELCOR 1.8.5. Options are available to allow acceptance of old decks, but conversion to the newer input requirements is strongly recommended. The following subsections provide more information.

1.5.1 Other Structures, SS, NS, and OS

In older versions of MELCOR, it was necessary to model control rods, control blades, core plates, CRGTs, and similar structures using a single "other structure" component, OS. This severely limited the fidelity with which such structures could be modeled. The default

modeling approach in MELCOR 1.8.5 is to represent supporting structures (such as core support plates and CRGTs) and nonsupporting structures (such as control rods/blades) as *separate* components, SS and NS, respectively. Although SS and NS components can represent only one type of structure in any given core cell, they may be used to represent quite different types of structures in different core cells.

The OS component and models based on it have been retained in MELCOR 1.8.5 for compatibility with older input decks, but may be eliminated from future versions of the code. The OS component cannot be combined with SS or NS in any input deck. In general, the capabilities of models for OS have not been upgraded beyond those in MELCOR 1.8.4. Conversion of a deck to use SS and NS requires moving masses of OS to either SS or NS on CORijj02 and CORijj02A input records. Parallel changes will be required for temperatures on CORijj03, equivalent diameters on CORijj04, and surface areas on CORijj06 records.

Acceptance of a deck with OS masses requires setting the model switch IOLDOS=1 on the COR00006 input record. Although this allows MELGEN to run to completion and generate a restart file, permitting MELCOR to be run, we do not recommend the practice because it prevents use of some of the improved models in MELCOR 1.8.5. However, used temporarily, it can aid in conversion of the deck.

If MELGEN runs to completion with IOLDOS=1 on the COR00006 input record, the output file will contain a set of suggested replacement records under the banner

```
^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^
<                                              >
<   INPUT FOR THIS CALCULATION USED IOLDOS=1   >
<   AND THE "OTHER STRUCTURE" COMPONENT "OS"   >
<                                              >
<   MANY IMPROVED MODELS REQUIRE CONVERSION    >
<    TO THE CURRENT DEFAULT REPRESENTATION     >
<   IOLDOS=0, WITH COMPONENTS "SS" and "NS"    >
<                                              >
<  USE THE FOLLOWING INPUT RECORDS TO CONVERT  >
<   (NOT ALL NEEDED IF REFERENCE CELLS USED)   >
<                                              >
 vvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvv
```

An attempt is made to infer whether original OS in each cell should be converted to NS or to SS. This is based on the value of the old support flag (ISUP on record CORZjj02) and the presence or absence of control poison, but may be incorrect because of the ambiguous nature of OS. All CORijjKNS and CORijjKSS records should therefore be examined, and converted from NS to SS, or vice versa, if necessary. If this is done, changes to these records may be necessary because the list of materials permitted for the two components is different, and areas on CORijj04 records must be switched.

Further changes may be needed to deal with errors resulting from the use of reference cells on CORijj01 input records. The problem arises if a core cell containing SS refers to one containing only NS, or vice versa, so that needed input cannot be found. This may require that the contents of one or more cells be fully defined, and/or that the cell referenced on one or more CORijj01 records be changed.

The resulting modeling of support of NS and SS may or may not be appropriate. By default, NS will be interpreted as representing a control rod for a PWR or a control blade for a BWR. SS will be interpreted as representing a grid-supported plate that fails on temperature. These defaults can be overridden by input on CORxxxNS and/or CORxxxSS input records, where "xxx" can be "000", "Zjj", "Rii", or "ijj". For the CRGTs in a BWR, it will be necessary to specify ISSMOD as "COLUMN" on CORxxxSS records. If CORZjj04 or CORijj07 records were used to modify the failure model for OS, these conditions will also need to be translated to the new format to preserve the previous modeling.

Conversion of an older input deck provides an opportunity to consider what behavior is <u>really</u> wanted for supporting and nonsupporting structures, without the constraints of the original models for OS. The MELGEN output file will contain a detailed summary of the models and options in effect in each core cell.

1.5.2 Input Variables NTLP and IAXSUP

There are two variables in the COR package input that might be assumed to define the position of the Core Support Plate (CSP). These are NTLP, on the COR00000 record, and IAXSUP, on the COR00012 record. These variables are used differently, but their usage in previous versions of MELCOR was not consistent. The issue of core component support, based on the input of ISUP on CORZjj02 records, further complicated the issue.

The usage has been revised and clarified in MELCOR 1.8.5. Input of NTLP, described as the "number of axial levels in the lower plenum" is required. Input of IAXSUP, described as the "level…containing the core support plate," is optional, with a default of NTLP.

NTLP is now used <u>only</u> as the default value for IAXSUP and, for calculations using the BH package, as the definition of the lowest level that will not be subsumed into BH. The value of IAXSUP, which can differ from NTLP as a result of explicit input on the COR00012 record, is now used for the location of the CSP in all uses within the COR package. These are: (1) the starting point for the falling debris quench model; and (2) the transition point between in-core and lower-plenum refreezing logic, and (3) special treatment of conduction and spreading for old decks using OS.

Following a suggestion from MCAP, we have added a "plausibility check" in MELGEN on the value in use for IAXSUP. A warning will be issued if it is not the lowest level containing an SS PLATE for input using SS, or the lowest level containing OS with full support

(ISUP=11) for input using OS. The warning indicates whether the value in use is the default value (NTLP) or was explicitly input.

1.5.3 Consistency with Volume Data in CVH

Materials in the COR package displace fluid in the CVH package. Thus, when core debris is moved from one location to another, additional volume becomes available to fluids in the original location, with an equivalent volume subsequently denied to fluids in the new location. However, the initial distribution of fluid volume in the core region is specified independently in input to the COR and CVH packages. (This was motivated by the modular nature of MELCOR and the desire to allow independent spatial nodalizations in COR and CVH.) The nodalizations used are often quite different.

The COR package keeps track of occupied volume within its own nodalization, and communicates any changes to CVH. There, the corresponding changes are made within the CVH nodalization, and the results are used in advancing the hydrodynamic equations. It is thus important that the two representations of volume remain consistent. This is necessary to allow a correct calculation of water levels, and to avoid the possibility of overfilling CVH fluid volumes with core debris.

In older versions of MELCOR, the COR package could not properly account for the distinction between particulate debris in the channel and in the bypass, making it impossible to maintain consistency for a BWR as core degradation proceeded. That deficiency has been removed in MELCOR 1.8.5 and, if the initial representation of volume is consistent, it should remain consistent. A comparison of the distribution of fluid volume in COR and CVH has been added as a part of the second pass of input processing in the COR package.

If any discrepancies are found, an error message is written to the MELGEN diagnostic file and the errors are flagged in the table. The specific requirement is that the initial total fluid volume in COR lying within any Volume/Altitude (V/A) segment of a CVH control volume cannot exceed the fluid volume in that V/A segment. If this condition is met, filling the entire fluid volume in COR with debris cannot overfill CVH.

Acceptance of inconsistent volumes requires setting the model switch ICORCV=1 on the COR00006 input record. Used temporarily, it can aid in conversion of the deck, as will be discussed below. Although this allows MELGEN to run to completion and generate a restart file, permitting MELCOR to be run, we do not recommend the practice. The major risk is that fluid volumes in CVH will become overfilled by particulate debris from COR. If this occurs, mass and energy will continue to be conserved, but the representations of fluid volumes in CVH and COR will become inconsistent, and other results may appear non-physical (at least on close inspection).

In general, the cross-sectional area of each cell in a ring should agree with the "total cross-sectional area" of each ring, ASCELA, as input on the appropriate CORRii01 record. A table of cell cross-sectional areas, calculated from the total cell volume (the total of the channel and the bypass in a BWR) divided by the cell height, has been added to the MELGEN edit. This allows the user to compare cell areas to ring areas, and significant discrepancies probably indicate that the values input for AFLOWC and/or AFLOWB are inappropriate.

Once the volumes within COR appear reasonable, consistency with CVH should be addressed. Within CVH, the vertical distribution of volume is defined only within the resolution provided by the V/A table for the CVH volume. The most detailed agreement with COR will be obtained if the elevations in the CVH V/A table match those in the core nodalization. This approach could not be recommended with MELCOR 1.8.4, at least for BWRs, because it exacerbated problems arising from limitations in the representation of volumes in COR. We now wish to encourage users to try it with MELCOR 1.8.5, for which the limitation has been removed. Therefore, the two nodalizations are compared as part of input processing in the COR package. Warning messages are generated unless there are points in the appropriate CVH V/A tables in CVH input to correspond to all axial limits of core cells in COR input, with details included as part of MELGEN output.

A detailed comparison of the distribution of fluid volumes in COR and in CVH appears in a table in the MELGEN output file following the header

```
***** CORE PACKAGE PASS 2 SETUP EDIT *****

      CONSISTENCY CHECK ON VOLUME REPRESENTATIONS IN COR AND CVH
```

If the V/A table includes points for every level in the COR nodalization, it is a relatively simple task to make the distribution of volumes consistent. Use of the option to specify volume increments rather than totals on CVnnnBk input records can significantly simplify this process by allowing the values from each COR level—slightly increased to provide a safety factor—to be input directly to CVH. If the resulting total volume is not correct, it may be necessary to reexamine the COR input and/or to consider the location of any regions in the CVH control volume that lie outside the core.

1.5.4 Debris Exclusion Modeling

Geometric considerations (such as the size of fuel pellets relative to interstitial spaces) may prevent particulate debris from entering regions of the core that would be accessible to molten materials. In older versions of MELCOR, the exclusion of particulate debris from the interior of fuel bundles could be modeled by using the "porosity" PORIN, input on CORZjj01 records. However, essentially similar effects, such as the possible exclusion of particulate debris from the bypass region of a BWR or from the control assemblies in VVER reactors, could not be modeled at all.

The original approach based on PORIN was non-intuitive, and hard to generalize. Moreover, PORIN was used in other, undocumented, ways. Therefore, the original model—and all other use of PORIN—have been replaced in MELCOR 1.8.5. In the new model, each intact component present in a core cell is permitted to exclude particulate debris from some fraction of the volume of that core cell, limited in some cases to the channel or bypass region.

In many cases, no changes in input will be required. By default, intact fuel rods exclude particulate debris from the entire channel region. In a BWR, intact NS (presumed to represent control blades) excludes it from a volume that approximates the bladed portion of the bypass, and intact CN (canister not adjacent to control blades) excludes it from the unbladed portion.

Conversion of an older input deck provides an opportunity to consider what behavior is really wanted, without the constraints of the old model. New possibilities can be modeled, and considerable flexibility is available through input on CORxxxDX, where "xxx" can be "000", "Zjj", "Rii", or "ijj". The model is further described in Section 3.2.3 of the COR Package Reference Manual. The MELGEN output file contains a detailed summary of the options in effect in each core cell in the current calculation.

1.5.5 Core Flow Blockage

The core flow blockage model in MELCOR 1.8.4 was compromised by the limited ability of COR to distinguish the channel and bypass regions of a BWR. Whereas the original blockage model had to be based on the total fluid volume in both regions, more detailed flow blockage options have been defined in MELCOR 1.8.5 that distinguish channel and bypass. In addition, a new model has been included that allows the opening of a flow path between the channel and bypass regions on failure of the separating canister boxes. See Section 2.9.1 and the description of the FLnnnBk input record in the Flow Path Package Users' Guide for details.

Older input decks using the flow blockage model should be examined to determine if one of the new options is more appropriate. For decks that did not use the option, conversion provides an opportunity to consider whether the revised model could be used to advantage.

2. Input Requirements

This section gives the input requirements for the MELCOR COR package, including a short description of the input quantities and their units and default values, if any. Further description of the input variables and their meaning in the models can be found in the COR Package Reference Manual. It is strongly recommended that the beginning user consult

both documents (as well as other packages' Users' Guides) when first learning these input requirements.

Input record identifiers for the COR package all begin with the character string "COR"; several are required, but most are optional with defaults provided or obtained from previous input for other cells. Record identifiers between COR00000 and COR00012, COR000DX, COR000NS, and COR000SS are used to specify general information about the geometry, nodalization, and physics modeling for the core and lower plenum as a whole. Record identifiers of the form CORZjjnn (nn = 01, 02, 03, 04, DX, NS, or SS) are used to specify information about axial level jj. Record identifiers of the form CORRiinn (nn = 01, 02, 03, DX, NS, or SS) are used to specify information about radial ring ii. Record identifiers of the form CORijjnn (nn = 01, 02, 02A, 03, 04, 05, 06, 07, DX, NS, or SS) are used to specify information about an individual core cell in radial ring i and axial level jj. For example, record COR31201 would specify information for cell 312, located in radial ring 3 and axial level 12. Records identifiers of the form CORijjKcc and CORijjYcc may optionally be used to define the initial masses of core components in a flexible form that allows specification of a degraded state, including oxidation, particulate debris, and conglomerate debris on all possible components.

Record identifiers of the form CORLHDii, CORLHNnn, and CORPENnn (ii and nn are sequence numbers) are used to specify information about the lower head and associated penetrations. Although their use is no longer either required or recommended, record identifiers of the form CORTINxx may optionally be used to specify the manner in which the inlet temperature for a core control volume is calculated in the core dT/dz model.

Hydrogen and carbon monoxide (CO) must be defined in the input for the NonCondensible Gas (NCG) package whenever the COR package is active. For BWR cores containing B_4C, the gases O_2, CO_2 and CH_4 must also be defined in NCG input.

2.1 MELGEN General Core/Lower Plenum Input

COR00000 – Nodalization Parameters
Required

This record specifies the core/lower plenum nodalization parameters and is required. Note that the number of material layers in the lower head will be one less than the number of temperature nodes (NLH-1) because the temperature nodes are defined at the layer boundaries. The first six fields must be present:

NTLP is used as the default for IAXSUP on optional input record COR00012. IAXSUP is used to define the position of the core support plate in some models. If the two are not equal (as a result of explicit input for IAXSUP), the value of NTLP is used only if the BH package is active. It then defines the lowest level in the core

nodalization that will not be subsumed into BH when the models in that package are initiated. See also Section 1.5.2 and the description of input record COR00012.

(1) NRAD - Number of radial rings in the core and lower plenum (maximum=9).
(type = integer, default = none, units = none)

(2) NAXL - Total number of axial levels in the core and lower plenum (maximum=99).
(type = integer, default = none, units = none)

(3) NTLP - Number of axial levels in the lower plenum only (maximum=49). NTLP must be less than NAXL.
(type = integer, default = none, units = none)

(4) NCVOL - Number of CVH fluid volumes in the core and lower plenum region.
(type = integer, default = none, units = none)

(5) NLH - Number of temperature nodes in the vessel lower head (maximum=24).
(type = integer, default = none, units = none)

(6) NPNTOT - Total number of representative lower head penetrations modeled (maximum=19, no more than 3 per ring, but cannot use 3 for each of 9 rings).
(type = integer, default = none, units = none)

(7) NINSLH - Total number of insulation (non-load bearing) mesh layers in the vessel lower head (maximum = NLH-1).
(type = integer, default = 0, units = none)

COR00001 – Geometric Parameters
Optional

This record specifies key geometric information for the fuel rods, control rods, and (for BWRs) canister boxes. If this record is present, it may contain from zero to seven fields. Default values will be retained for those fields that are not present and for any that contain negative numbers. Different default values are defined for a BWR (including SBWR) or a PWR, based on IRTYP input on record COR00002. These are marked as "(B)" and "(P)", respectively, in the list below.

(1) RFUEL - Outer radius of the fuel pellets in the fuel rods.
(type = real, default = 0.00521 (B) or 0.00464 (P), units = m)

(2) RCLAD - Outer radius of the fuel rod cladding.
(type = real, default = 0.00613 (B) or 0.00536 (P), units = m)

(3) DRGAP - Thickness of the gas gap between fuel pellets and cladding.
(type = real, default = 0.00012 (B) or 0.00011 (P), units = m)

(4) PITCH - Center-to-center spacing of the fuel rods.
(type = real, default = 0.0162 (B) or 0.0143 (P), units = m)

(5) DXCAN - Thickness of the canister wall.
(type = real, default = 0.0025 (B) or 0.0 (P), units = m)

(6) DXSS - Thickness of "other structure."
(type = real, default = 0.0014 (B) or 0.00036 (P), units = m)

(7) DZLH - Thickness of lower head.
(type = real, default = 0.22 (B) or 0.13 (P), units = m)

DXCAN and DXSS are not currently used in the calculation.

COR00002 – Reactor Type
Optional

This record specifies the reactor type, the control rod poison material, and the electric heating element material. This record is not required, but if included, at least the first field must be present. Three character string fields are allowed:

(1) IRTYP - Reactor type. Three choices are allowed: 'BWR', 'PWR', and 'SBWR'.
(type = character*4, default = 'BWR')

(2) MCRP - Control rod poison material. Only two choices are allowed: 'B4C' and 'AG-IN-CD'.
(type = character*8, default = 'B4C')

(3) MATHT - Electric heating element material.
(type = character*24, default = none)

COR00003 – Radiative Exchange Factors
Optional

This record specifies the radiative exchange factors used to model thermal radiation in the core. These exchange factors roughly correspond to the traditional view

factors describing the geometric orientation between two pairs of surfaces. This record is not required, but if included, the following five fields must be present. Each value must be a nonnegative real number less than or equal to 1.0. For more details on the interpretation given to these parameters, see the COR Package Reference Manual, Section 2.1.2.

(1) FCNCL - Radiative exchange factor for radiation from the canister wall to the fuel rod cladding. A value must be entered for PWRs, but is not used.
(type = real, default = 0.25, units = none)

(2) FSSCN - Radiative exchange factor for radiation from "other structure" (e.g., control blades) to the adjacent canister walls or to fuel rods and debris if canister is not present.
(type = real, default = 0.25, units = none)

(3) FCELR - Radiative exchange factor for radiation radially outward from the cell boundary to the next adjacent cell.
(type = real, default = 0.25, units = none)

(4) FCELA - Radiative exchange factor for radiation axially upward from the cell boundary to the next adjacent cell.
(type = real, default = 0.25, units = none)

(5) FLPUP - Radiative exchange factor for radiation from the liquid pool to the core components.
(type = real, default = 0.25, units = none)

COR00004 – TP Interface and Fission Power and Gap Conductance Control Functions Required

This record specifies the Transfer Process package translation matrix number (for transfer of mass and energy to the Cavity Package); it may also specify the fission power and fuel—cladding gap conductance control function numbers. This record is required and must contain at least the first of the three allowed integer fields.

(1) NTPCOR - 'In' Transfer Process number ('nnn' on the TPINnnn00 record) that specifies the input for transferring masses and energies from the COR package to the Cavity or FDI packages. For convenience, a value of 0, indicating no TP, may be used for calculations that will not fail the lower head and eject debris. The number of masses and the number of thermodynamic variables on the TPINnnn00 record must be NMSIN=6 and NTHRM=9. Also, on the corresponding TPMnnn0000 record, NCOL=6. The order of

masses ejected for generating the translation matrix in the corresponding TPMnnnkkkk records is: (1) UO_2, (2) Zr, (3) steel, (4) ZrO_2, (5) steel oxide, and (6) control poison. Inconel is included with steel automatically. See the Transfer Process Package Users' Guide for more details.
(type = integer, default = none, units = none)

(2) ICFFIS - Fission power control function number. If 0 or omitted, no fission power is calculated. If positive, control function ICFFIS is used to calculate the liquid water level to be used in the Chexal-Layman fission power/liquid level correlation (see Section 2.6 of the COR Package Reference Manual). If negative, control function -ICFFIS is used to calculate the whole-core fission power. If |ICFFIS| is less than 100, fission power is distributed over all core cells (not lower plenum cells) on a per fuel mass basis. If |ICFFIS| is greater than or equal to 100, fission power is distributed only over liquid-covered cells containing intact fuel. Decay heat is <u>added</u> to the fission power to obtain total core power, so the user input value should <u>not</u> include the contribution from fission product decay.
(type = integer, default = 0, units = none)

(3) ICFGAP - Fuel-cladding gap conductance control function number. If 0 or omitted, no additional gap resistance is calculated. If a positive value is entered, the conductance is added serially to the gap gas conduction for all cells with fuel rods, in parallel to the gap radiation.
(type = integer, default = 0, units = none)

COR00005 – Candling Heat Transfer Coefficients
Optional

This record specifies the refreezing heat transfer coefficients to be used in the candling model for each of the molten core materials. This record is not required, but if included, the following six fields must be present. Each value must be positive. Due to a large degree of phenomenological uncertainty, it is very difficult to justify particular values for these coefficients. The default values are order-of-magnitude estimates that appear to produce plausible simulations of relocation phenomena, but they should be varied in sensitivity studies to determine their impact on overall melt progression behavior. For more information on how these quantities are used in the candling model, see the COR Package Reference Manual, Section 3.1.

(1) HFRZUO - Refreezing heat transfer coefficient for UO_2.
(type = real, default = 1000.0, units = W/m^2-K)

(2) HFRZZR - Refreezing heat transfer coefficient for Zircaloy.
(type = real, default = 1000.0, units = W/m^2-K)

(3) HFRZSS - Refreezing heat transfer coefficient for steel.
(type = real, default = 1000.0, units = W/m^2-K)

(4) HFRZZX - Refreezing heat transfer coefficient for ZrO_2.
(type = real, default = 1000.0, units = W/m^2-K)

(5) HFRZSX - Refreezing heat transfer coefficient for steel oxide.
(type = real, default = 1000.0, units = W/m^2-K)

(6) HFRZCP - Refreezing heat transfer coefficient for the control poison material.
(type = real, default = 1000.0, units = W/m^2-K)

COR00006 – Model Switches
Optional

This record activates or deactivates various models and options. The default values of IHSDT, IDTDZ, IOLDOS, and ICORCV are strongly recommended.

Problems with the materials interaction model in MELCOR 1.8.3 have been reported. Some of these have been resolved in later versions, but use of the model is not recommended at this time. As discussed in Section 1.4, many of the effects of materials interactions may be captured without activating the model.

The core model in MELCOR 1.8.5 allows representation of supporting structures (such as core support plates) and nonsupporting structures (such as control rods/blades) as *separate* components, *SS* and *NS*, respectively. The single "other structure" component, *OS*, used in older versions of MELCOR is still available for compatibility with older input decks, but may not be retained in future versions. Its use requires setting the model switch IOLDOS=1. Mixing of the two representations is not permitted. See Section 1.5 for help in converting older input decks to the new representation.

The core model in MELCOR 1.8.5 allows a consistent representation of volumes in the COR package and that in CVH to be maintained for all reactors as core degradation progresses. In previous versions, this was not true for BWRs. The initial representations are now compared as part of input processing. Apparent discrepancies are noted, and comparison tables are provided as part of MELGEN output. Warning and/or error messages may also be generated.

If a severe discrepancy is found, no restart file will be written. The specific requirement is that the initial total fluid volume in COR lying within any Volume/Altitude segment of a CVH control volume cannot exceed the fluid volume in that V/A segment. If this condition is met, filling the entire fluid volume in COR with debris cannot overfill CVH. The requirement may be bypassed by setting the model switch ICORCV=1. See Section 1.5.3 for help in converting older input decks to the new representation.

(1) IEUMOD - Materials interactions model switch
= 0 Model is inactive
= 1 Model is active.
(type = integer, default = 0, units = none)

(2) IHSDT - HS boundary condition option switch
= 0 dT/dz boundary condition option required for core radial boundary structures input on record CORZjj02
= 1 dT/dz boundary condition option not required.
(type = integer, default = 0, units = none)

(3) IDTDZ - dT/dz inlet specification option switch.
= 0 dT/dz inlet flow and temperature from default hydrodynamic calculation in CVH/FL. For this option, CORTIN records are *not allowed* as part of MELGEN input.
= 1 dT/dz inlet flow and temperature calculated as in MELCOR 1.8.3, with the addition of a downward-flow option. For this option, CORTIN records are *required* for at least the lowest and highest hydrodynamic control volumes containing core cells.
(type = integer, default = 0, units = none)

(4) IOLDOS - Other Structure option switch.
= 0 Input may not contain specification of OS. Structures must be modeled using SS and NS.
= 1 Input may not contain specification of either SS or NS; only OS may be used to model structures.
(type = integer, default = 0, units = none)

(5) ICORCV - CVH volume consistency switch.
= 0 Consistency between fluid volumes in CVH and in COR, in the sense that the volume in COR may not exceed that in CVH, is required.

= 1 Consistency between fluid volumes in CVH and in COR is not required.
(type = integer, default = 0, units = none)

COR00007 – Candling Secondary Material Transport Parameters
Optional

This record specifies the parameters needed to model the transport of secondary materials during candling. This record is not required, but if included, the following eight fields must be present. Transport mechanism 1 dictates that secondary material is relocated as a fraction of the molten mass specified by the transport parameter. Transport mechanism 2 dictates that secondary material is relocated in fractional proportion, as specified by the transport parameter (with a value of 1.0 indicating direct proportionality), to its existing fraction within a component. For more detailed information on how these parameters are used in the candling model, see the COR Package Reference Manual, Section 3.1.

(1) MTUOZR - Transport mechanism flag for UO_2 in molten Zircaloy.
(type = integer, default = 1, units = none)

(2) MTZXZR - Transport mechanism flag for ZrO_2 in molten Zircaloy.
(type = integer, default = 1, units = none)

(3) MTSXSS - Transport mechanism flag for steel oxide in molten steel.
(type = integer, default = 2, units = none)

(4) MTCPSS - Transport mechanism flag for control poison material in molten steel.
(type = integer, default = 2, units = none)

(5) FUOZR - Transport parameter for UO_2 in molten Zircaloy.
(type = real, default = 0.2, units = none)

(6) FZXZR - Transport parameter for ZrO_2 in molten Zircaloy.
(type = real, default = 0.0, units = none)

(7) FSXSS - Transport parameter for steel oxide in molten steel.
(type = real, default = 1.0, units = none)

(8) FCPSS - Transport parameter for control poison material in molten steel.
(type = real, default = 0.0, units = none)

COR00008 – Component Critical Minimum Thicknesses
Optional

This record specifies minimum thicknesses for cladding and "other structure" to maintain material intact (i.e., prevent material from becoming particulate debris). This record is not required, but if included, the following two fields must be present. Each value must be positive. The defaults are *ad hoc* values that should be varied in sensitivity studies to determine their impact on core degradation behavior. For more information on how these parameters are used in the debris formation model, see the COR Package Reference Manual, Section 3.2.1.

(1) DRCLMN - Critical minimum thickness of unoxidized Zircaloy in cladding or canister. Set to 0.0 to allow uncollapsed "bare" fuel pellets to survive to a temperature set by sensitivity coefficient 1132.
(type = real, default = 0.0001, units = m)

(2) DRSSMN - Critical minimum thickness of unoxidized steel in "other structure."
(type = real, default = 0.0001, units = m)

COR00009 – Lower Head Failure Modeling Parameters
Optional

This record specifies parameters needed to model failure of the vessel lower head and its penetrations. This record is not required, but if included, the following four fields must be present. The default heat transfer coefficients are order-of-magnitude parameters that should be varied in sensitivity studies to determine their impact on lower head heat transfer and failure. The default failure temperature is an approximate value for the transition to plastic behavior for steel. For more information on how these parameters are used in the lower head failure model, see the COR Package Reference Manual, Section 4.

(1) HDBPN - Heat transfer coefficient from debris to penetration structures.
(type = real, default = 1000.0, units = W/m^2-K)

(2) HDBLH - Heat transfer coefficient from debris to lower head.
(type = real, default = 1000.0, units = W/m^2-K)

(3) TPFAIL - Failure temperature of the penetrations or the lower head.
(type = real, default = 1273.15, units = K)

(4) CDISPN - Discharge coefficient for ejection of debris through failed penetration opening.
(type = real, default = 1.0, units = none)

COR00011 – Core Boundary Conduction Parameters
Optional

This record specifies parameters for calculating conduction from the outer core ring to the boundary heat structures specified on record CORZjj02. This record is not required, but if included, the following four fields are required. For more information on how these parameters are used in the conduction model, see the COR Package Reference Manual, Section 2.2.7.

(1) ICBCD - Component number that conducts to boundary heat structures (see Section 1.1 for component numbers).
(type = integer, default = none, units = none)

(2) MATBCD - Gap material for conduction to boundary heat structures.
(type = character*24, default = none, units = none)

(3) DXBCD - Gap thickness.
(type = real, default = none, units = m)

(4) CDFBCD - Boundary conduction thermal diffusion constant.
(type = real, default = none, units = m^2-K-$s^{1/2}$/J)

COR00012 – In-Vessel Falling Debris Quench Model Parameters
Optional

This record specifies parameters needed to activate the in-vessel falling debris quench model. This record is not required, but if included, the first field must be present, while the following three fields are optional. For more information on how these parameters are used in the model, see the COR Package Reference Manual, Section 2.3.7.

There are other uses of IAXSUP but, in most cases, the value defaulted from NTLP on input record COR00001 will be appropriate. See section 1.5.2 for more discussion.

(1) HDBH2O - Heat transfer coefficient from in-vessel falling debris to pool. A value of zero turns the model off. *User Note: Large values of this parameter could result in vessel over-pressurization.*
(type = real, default = 100.0, units = W/m^2-K)

(2) PPFAIL - Differential pressure between lower plenum volume and reactor cavity volume that will fail the lower head. This value must not exceed the critical pressure of water (2.2e7 Pa) or a fatal input error will result.

(type = real, default = 2.0e7, units = Pa)

(3) IAXSUP - Axial level number of core cells containing the core support plate. It is used primarily as the starting point for tracking falling debris. (type = integer, default = NTLP [see description of input record COR00000], units = none)

(4) VFALL - Velocity of falling debris.
(type = real, default = 1.0 [*In previous versions of MELCOR this value was default to 5 m/s. The current default reflects greater resistance to falling offered by the water and rising bubbles.*], units = m/s)

COR000DX – Global Particulate Debris Exclusion Parameters
Optional

This record allows global definition of volumes from which particulate debris will be excluded by the simple presence of various other components. The exclusion volumes are specified as fractions of the associated total volume, either channel or bypass. (Particulate debris will be excluded from the physical volume of the component even if this fraction is zero.) The model is described briefly in Sections 1.4 and 1.5.4 of this manual and in detail in Section 3.2.3 of the COR Package Reference Manual.

If this record is present, it may contain from zero to seven fields. Default values will be retained for those fields that are not present and for any that contain negative numbers. The default value for FBYXNS is different for a BWR (including SBWR) than for a PWR. The choice is based on IRTYP input on record COR00002.

(1) FCHXRD - Fraction of channel volume denied to particulate debris by presence of fuel rods, FU and/or CL.
(type = real, default = 1.0, units = none)

The following three fractions are used only in cells where there is a distinct bypass.

(2) FBYXRD - Fraction of bypass volume denied to particulate debris by presence of fuel rods, FU and/or CL.
(type = real, default = 0.0, units = none)

(3) FBYXCN - Fraction of bypass volume denied to particulate debris by presence of canister, CN.
(type = real, default = 0.3, units = none)

(4) FBYXCB - Fraction of bypass volume denied to particulate debris by presence of bladed canister, CB.
(type = real, default = 0.0, units = none)

The following three fractions are applied to the bypass volume in cells where there is a distinct bypass. Otherwise, they are applied to the total cell volume.

(5) FBYXNS - Fraction of applicable volume denied to particulate debris by presence of nonsupporting structure, NS.
(type = real, default = 0.7 for BWR, 0.0 for PWR, units = none)

(6) FBYXSS - Fraction of applicable volume denied to particulate debris by presence of supporting structure, SS.
(type = real, default = 0.0, units = none)

(7) FBYXOS - Fraction of applicable volume denied to particulate debris by presence of combined other structure, OS.
(type = real, default = 0.0, units = none)

COR000NS – Global Support Rule for NS
Optional

The primary use of the NS component in modeling a commercial reactor is to represent control structures (blades and rods). This record defines the global rule for support of NS in the core. The record is optional, and the default treatment depends on the reactor type (IRTYP on the COR00002 input record). If the record is input with less than four fields, default values will be used for the omitted field(s).

(1) INSSUP - Support rule for NS.
= 'BELOW' NS in a cell will collapse unless there is intact NS or unfailed SS in the cell immediately below it.
= 'ABOVE' NS in a cell will collapse unless there is intact NS in the cell immediately above it.
= 'FIXED' NS in a cell will not collapse until it fails locally.
= 'BLADE' Converted internally to 'BELOW' for all cells.
= 'ROD' Converted internally to 'ABOVE' for all cells except for the top axial level, where 'FIXED' will be specified.
(type = character*6 default = 'BLADE' for a BWR or SBWR, and 'ROD' for a PWR, units = none)

(2) METAL - Structural metal in NS.
= 'STEEL' Local failure is based on the thickness of steel in NS.

= 'ZIRC' Local failure is based on the thickness of Zircaloy in NS.
(type = character*6, default = 'STEEL', units = none)

(3) TNSMAX - Temperature above which NS will collapse, independent of remaining metal thickness. A zero or negative value implies collapse at the melting point of METAL.
(type = real, default = 0.0, units = K)

(4) DRNSMN - Critical minimum thickness of unoxidized metal in NS, below which it will collapse.
(type = real, default = 0.0001, units = m)

COR000SS – Global Loading and Failure Rule for SS
Optional

The primary use of the SS component in modeling a commercial reactor is to represent supporting structures such as core plates and control rod guide tubes. This record defines the global rule for loading and failure of SS. The options are described briefly in Section 1.3 of this report, and in more detail in the COR Package Reference Manual.

The record is optional. The first field defines the structural model, while second and subsequent fields provide parameters for the failure calculation, which may be either parametric or stress based. The default treatment is as a grid supported plate ('PLATEG') with failure on overtemperature, which closely resembles the model used for OS. If the record is input with less than the maximum permitted number of fields for the model specified in the first field, default values will be used for the omitted field(s).

(1) ISSMOD - Structural model option for SS.
= 'PLATE' SS in a cell will be treated as an edge-supported plate.
= 'PLATEG' SS in a cell will be treated as a grid-supported plate.
= 'PLATEB' SS in a cell will be treated as a BWR core plate.
= 'COLUMN' SS in a cell will be treated as a column representing a BWR control rod guide tube.
(type = character*6, default = 'PLATEG', units = none)

For parametric models, the second field is a character variable specifying the model, and the interpretation of the third field depends on the model specified.

(2) ISSFAI - Failure model, either 'TSFAIL' or 'LOG-CF'.
(type = character*6, default = 'TSFAIL', units = none)

followed by either

(3) TSSFAI - Failure temperature for the TSFAIL model
(type = real, default = 1273.15, units = K)

or

(3) ISSLCF - Number of a logical control function for the LOG-CF model. A .TRUE. value will define failure of the SS.
(type = integer, default = none, units = none)

For stress-based failure modeling, fields 2 through 4 define the parameters to be used in converting total loads borne by a structure. Their interpretation depends on the structural model option specified in field 1.

For the PLATE model, the stress at radius r in a plate of thickness h and radius a with a central hole of radius r_0, bearing a total load W_{total} is computed as

$$\sigma_e(r;r_0) = 6\,K_0\,\frac{1}{\pi}\frac{1}{h^2}\left[1-K_1\left(\frac{r}{a}\right)^2\right]\left[1+\left(\frac{r_0}{r}\right)^2\right]W_{total} \qquad \text{(PLATE)}$$

The input parameters are

(2) THICK - Working thickness of plate, h, used only for stress calculations.
(type = real, default = none, units = m)

(3) AKM0 - Lead coefficient, K_0.
(type = real, default = 0.206, units = none)

(4) AKM1 - Coefficient K_1 in stress concentration term for central hole.
(type = real, default = 0.576, units = none)

For the PLATEG model, the maximum stress in a plate of thickness h supported by beams of spacing h with a total load, W_{total} on an area A_{ring} is computed as

$$\sigma_{e,ring} = 6\,K_G\,\frac{x^2}{A_{ring}}\frac{1}{h^2}W_{ring} \qquad \text{(PLATEG)}$$

The input parameters are

(2) THICK - Working thickness of plate, *h*, used only for stress calculations.
(type = real, default = none, units = m)

(3) SPACE - Spacing of supporting beams, *x*.
(type = real, default = none, units = m)

(4) AKMG - Coefficient K_G.
(type = real, default = 0.0513, units = none)

For the PLATEB model, the maximum stress in a plate of thickness *h* supported by beams of spacing *h* with a total load, W_{total} on an area A_{ring} is computed as

$$\sigma_{e,ring} = 6\, K_B \frac{x^2}{A_{ring}} \frac{1}{h^2} W_{ring} \qquad \text{(PLATEB)}$$

The input parameters are

(2) THICK - Working thickness of plate, *h*, used only for stress calculations.
(type = real, default = none, units = m)

(3) SPACE - Spacing of supporting beams, *x*.
(type = real, default = none, units = m)

(4) AKMB - Coefficient K_B.
(type = real, default = 0.0833, units = none)

For the COLUMN model, the maximum stress in a group of *N* identical cylindrical columns with initial outer radius r_o and inner radius r_i with a total load, W_{total} is computed as

$$\sigma_{e,ring} = \frac{1}{N\pi\left(r_o^2 - r_i^2\right)} \frac{M_{column,0}}{M_{column}} W_{ring} \qquad \text{(COLUMN)}$$

The factor of the ratio of the initial column mass to the current mass is included to account for any reduction of load bearing area by oxidation or melting. The input parameters are

(2) XNUM - Number of identical columns in ring, *N*
(type = real, default = none, units = none)

(3) RADO - Outer radius of column, r_o.

(type = real, default = none, units = m)

(4) RADI - Inner radius of column, r_i.
(type = real, default = 0.0, units = m)

COR000PC – Global Pool Heat Transfer from Bottom/Top of SS Plates
Optional

Unlike other core components, plates have horizontal bottom and top surfaces. When the SS component is used to model a plate, heat transfer from these surfaces to water pools below and/or above may be calculated. The model may be controlled independently for the two surfaces, and is off by default.

When the model is on, the total area of either surface is taken as the total cross-sectional area of the core cell. The fraction covered below is ramped on as the surface of the pool in the core cell below rises to the bottom surface of the plate. Similarly, the fraction covered above is ramped off as the surface of the pool in the core cell above falls to the top surface of the plate.

By default, the heat transfer coefficient for the bottom surface is evaluated from the built in correlation for downward-facing boiling and that for the top surface from the built-in pool boiling correlation. These may be overridden by constant values or by values calculated as control functions. In any case, the temperature difference is based on the average temperature of the plate in the core cell and that of the pool.

(1) DZBOT - Clearance between bottom of plate and pool surface for no contact. If negative, no heat transfer is considered between the bottom surface and the pool.
(type = real, default = -1.0, units = m)

(2) DZTOP - Pool depth over top surface of plate for complete coverage. If negative, no heat transfer is considered between the top surface and the pool
(type = real, default = -1.0, units = m)

optionally followed by either

(3) HPBOT - Constant heat transfer coefficient between bottom surface and pool to override the default boiling correlation.
(type = real, default 0.0, units = W/m^2K)

or

(3) IHPBOT - Number of a real control function whose value will be used as the heat transfer coefficient between bottom surface and pool. (type = integer, default = 0, units = none)

optionally followed by either

(4) HPTOP - Heat transfer coefficient between top surface and pool to override the default boiling correlation. (type = real, default 0.0, units = W/m^2K)

or

(4) ICFEMI - Number of a real control function whose value will be used as the heat transfer coefficient between top surface and pool. (type = integer, default = 0, units = none)

COR000PR – Global Downward Radiation from SS to Pool or Lower Head
Optional

By default, the general radiation model is used for radiation from the lowest surface in the core to a pool or the lower head below. The view-factor-times-area product is taken as FLPUP MIN(A_{surf}, ASCELA) or FCELA MIN(A_{surf}, A_{LH}), respectively. Here FLPUP and FCELA are values input on the COR00003 record (or associated defaults), ASCELA is input for each ring on CORRii01 records, and A_{LH} is derived from input on CORLHDii records. In some cases, this may not adequately represent actual radiative heat transfer from the core support plate. This record allows generalization of the calculation. It affects *only* the specific case of radiation from SS as the lowest surface in the core to a pool or the lower head below. The input parameters are

(1) ISSVFA - Number of a real control function whose value (subject to appropriate limits) will be used as the view-factor-times-area product for this radiation path. (type = real, default = none, units = none)

optionally followed by either

(2) EMISSS - Constant emissivity value to be used for the SS surface. (type = real, default none, units = none)

or

(2) ICFEMI - Number of a real control function whose value (subject to appropriate limits) will be used as the emissivity of the SS surface.
(type = integer, default = none, units = none)

2.2 MELGEN Axial Level Input

CORZjj01 – Axial Level Geometric Parameters
$1 \leq jj \leq NAXL$, jj is the axial level number
Required

This record specifies various geometric parameters for axial level jj. Four floating point fields are required for each level. PORIN is no longer used, but its input is retained to preserve the format of the record; parameters input on COR000DX, CORZjjDX, CORRiiDX, and/or CORijjDX records now provide much more flexible control of debris relocation.

(1) Z - Elevation of lower boundary of axial level.
(type = real, default = none, units = m)

(2) DZ - Axial length of level from lower boundary to upper boundary.
(type = real, default = none, units = m)

(3) PORIN - Unused.
(type = real, default = none, units = none)

(4) PORDP - Porosity of particulate debris for all cells in axial level jj. The value must be nonnegative and less than 1.0.
(type = real, default = none, units = none)

CORZjj02 – Radial Boundary Heat Structure Specification, Component Support Flag
$1 \leq jj \leq NAXL$, jj is the axial level number
Required

This record specifies the heat structure number representing the outer radial boundary for axial level jj and whether components in this level are initially supported by components in the cell below or by lateral support. The first of the two allowed integer fields specifies the heat structure that provides the radial thermal boundary for this axial level of the core, and is required for each level. Melting of these structures can be modeled through appropriate input to the HS package, using HSDGCCCCCn input records (see the HS package Users' Guide). When this

is done, the molten steel from the structure will be added to the outermost radial ring of the axial level containing the structure.

The second field defining the support of core components in this level is optional. It is used only when the combined other structure component, OS, is used (which requires setting IOLDOS=1 on input record COR00006). Although ISUP is defined initially for all cells in level jj, it may change in individual cells in that level according to cell temperatures (see input record CORZjj04).

If IOLDOS=0, any input for ISUP is unused. Instead, supporting structure (SS) is modeled as supporting itself, and as capable of supporting other structures until it reaches the failure temperature specified on input record CORZjj04 (equivalent to OS with ISUP=11). Nonsupporting structure (NS) is treated subject to the same support rules as other components such as cladding (CL) or canister (CN and CB), and cannot support other components.

(1) IHSA - Boundary heat structure number for this axial level. A unique heat structure must be specified for each axial level.
(type = integer, default = none, units = none)

(2) ISUP - Core component support flag, composed of two digits, used only for the OS component, which is allowed only if IOLDOS=1 on input record COR00006. If the first digit ("tens" digit) is nonzero, then the "other structure" component (e.g., the core plate) will support particulate debris, not allowing it to penetrate to lower axial levels, until the component reaches the structure failure temperature TSFAIL (record CORZjj04). If the first digit is 0 (or omitted), then particulate debris will not be supported by the "other structure" component at this level. If the second digit of ISUP ("ones" digit) is nonzero, intact components in cell jj will remain in that cell until they melt or form particulate debris. If the second digit is 0, an intact component in cell jj-1 must be present to support components in cell jj; otherwise these components will be converted to particulate debris.
(type = integer, default = 0, units = none)

CORZjj03 – Axial Power Density Profile
$1 \leq jj \leq NAXL$, jj is the axial level number
Optional

This record specifies the relative amount of fission power generated per unit fuel mass in axial level jj, as well as the relative amount of decay power per unit mass if the Radionuclide (RN) package is inactive. The sum of the values for all levels must be greater than 0.0 if ICFFIS on input record COR00004 is not 0 or if the RN

package is inactive. The values are normalized for all cells containing a fuel component for |ICFFIS| less than 100, or (for fission power only) for all liquid-covered cells containing fuel for |ICFFIS| greater than or equal 100. This record is not required, but if included, one floating point field must be present.

(1) FZPOW - Relative power density in this level.
(type = real, default = 1.0, units = none)

CORZjj04 – "Other Structure" Failure Temperature
$1 \leq jj \leq NAXL$, jj is the axial level number
Optional

This record defines temperature at which "other structure" will fail in axial level jj. This record is not required, but if included, one floating point field must be present. It is used only for the OS component, which is allowed only if IOLDOS=1 on input record COR00006.

(1) TSFAIL - "Other structure" failure temperature for cells in this level. "Failure" is currently defined with regard to the capacity of "other structure" components to support other intact components and particulate debris. It has the effect of resetting the "tens" digit of the support flag ISUP (input for all cells at level jj on input record CORZjj02) to zero when this temperature is reached in a cell.
(type = real, default = 1273.15, units = K)

CORZjjDX – Particulate Debris Exclusion Parameters in Axial Level
$1 \leq jj \leq NAXL$, jj is the axial level number
Optional

These records may be used to override the global (or default) parameters for modeling of particulate debris exclusion for all core cells in an axial level. The format and options are identical to those for the COR000DX input record.

CORZjjNS – Support Rule for NS in Axial Level
$1 \leq jj \leq NAXL$, jj is the axial level number
Optional

These records may be used to override the global (or default) definition of support of NS for all core cells in an axial level. The format and options are identical to those for the COR000NS input record with the exception that the 'BLADE' and 'ROD' options are not available because the input affects only a single axial level of the core.

CORZjjSS – Loading and Failure Rule for SS in Axial Level
$1 \leq jj \leq NAXL$, jj is the axial level number
Optional

These records may be used to override the global (or default) definition of modeling of SS for all core cells in an axial level. The format and options are identical to those for the COR000SS input record.

CORZjjPC – Pool Heat Transfer from Bottom/Top of SS Plates in Axial Level
$1 \leq jj \leq NAXL$, jj is the axial level number
Optional

These records may be used to override the global (or default) definition of modeling of heat transfer from SS plate surfaces for all core cells in an axial level. The format and options are identical to those for the COR000PC input record.

CORZjjPR –Downward Radiation from SS to Pool or Lower Head in Axial Level
$1 \leq jj \leq NAXL$, jj is the axial level number
Optional

These records may be used to override the global (or default) definition of modeling of downward radiation from SS for all core cells in an axial level. The format and options are identical to those for the COR000PR input record.

2.3 MELGEN Radial Ring Input

CORRii01 – Radial Ring Cross-sectional (Axial Boundary) Area
$1 \leq ii \leq NRAD$, ii is the radial ring number
Required

This record specifies the total axial cross-sectional area of radial ring ii, including all core components, channel flow area, and bypass flow area. This value is used in the radiation model for calculating axial inter-cell radiative energy exchange. It is not used in calculating core cell volumes. These are based on component volumes and fluid flow areas entered on CORijj05 records. One floating point field is required for each ring. For further details, see the COR Package Reference Manual, Sections 1.1 and 2.1.

(1) ASCELA - Total cross-sectional area of radial ring ii [equal to $\pi\left(R_o^2 - R_i^2\right)$, where R_o and R_i are the outer and inner radii of ring ii].
(type = real, default = none, units = m^2)

CORRii02 – Upper Boundary Heat Structure and Lower Head Failure CF Specification
1 ≤ ii ≤ NRAD, ii is the radial ring number
Required

This record specifies the heat structure number representing the upper axial boundary for radial ring ii and optionally a control function to trigger lower head failure for this ring. At least the first integer field is required for each level. Melting of these structures can be modeled through appropriate input to the HS package, using HSDGCCCCCn input records. When this is done, the molten steel from the structure will be added to the outermost radial ring of the uppermost axial level of the core.

(1) IHSR - Upper boundary heat structure number for this radial ring.
(type = integer, default = none, units = none)

(2) ICFLHF - If ICFLHF > 0, a value of .TRUE. calculated by a logical control function with user number ICFLHF will trigger failure of the lower head penetrations in this radial ring.
(type = integer, default = 0, units = none)

CORRii03 – Radial Power Density Profile
1 ≤ ii ≤ NRAD, ii is the radial ring number
Optional

This record specifies the relative amount of fission power generated per unit fuel mass in radial ring ii, as well as the relative amount of decay power per unit mass if the Radionuclide (RN) package is inactive. The sum of the values for all rings must be greater than 0.0 if ICFFIS on input record COR00004 is not 0 or if the RN package is inactive. The values are normalized for all cells containing a fuel component for |ICFFIS| less than 100, or (for fission power only) for all liquid-covered cells containing fuel for |ICFFIS| greater than or equal 100. This record is not required, but if included, one floating point field must be present.

(1) FRPOW - Relative power density in this ring.
(type = real, default = 1.0, units = none)

CORRii04 – Ring Flow Direction Control Functions
1 ≤ ii ≤ NRAD, ii is the radial ring number
Optional

This record allows the use of control functions to specify the direction of flow to be assumed in the oxidation calculation, and the order in which core cells within a ring will be given access to available oxidizers. If a nonzero number is entered, the

direction will be inferred from the value of the specified control function, with a positive value taken to imply upflow and a negative value to imply downflow.

(1) ICFCHN - The number of a REAL control function from which the direction of flow in the channel will be inferred.
(type = integer, default = 0, units = none)

(2) ICFBYP - The number of a REAL control function from which the direction of flow in the bypass will be inferred.
(type = integer, default = 0, units = none)

CORRiiDX – Particulate Debris Exclusion Parameters in Radial Ring
$1 \leq ii \leq NRAD$, ii is the radial ring number

These records may be used to override the previous definition of particulate debris exclusion parameters for all core cells in a radial ring. The format and options are identical to those for the COR000DX input record.

CORRiiNS – Support Rule for NS in Radial Ring
$1 \leq ii \leq NRAD$, ii is the radial ring number
Optional

These records may be used to override the previous definition of support of NS for all core cells in a radial ring. The format and options are identical to those for the COR000NS input record.

CORRiiSS – Loading and Failure Rule for SS in Radial Ring
$1 \leq ii \leq NRAD$, ii is the radial ring number
Optional

These records may be used to override the previous definition of modeling of SS for all core cells in a radial ring. The format and options are identical to those for the COR000SS input record.

CORRiiPC – Pool Heat Transfer from Bottom/Top of SS Plates in Radial Ring
$1 \leq ii \leq NRAD$, ii is the radial ring number
Optional

These records may be used to override the global (or default) definition of modeling of heat transfer from SS plate surfaces for all core cells in a radial ring. The format and options are identical to those for the COR000PC input record.

CORRiiPR –Downward Radiation from SS to Pool or Lower Head in Radial Ring
1 ≤ ii ≤ NRAD, ii is the radial ring number
Optional

These records may be used to override the global (or default) definition of modeling of downward radiation from SS for all core cells in a radial ring. The format and options are identical to those for the COR000PR input record.

2.4 MELGEN Specific Cell Input

CORijj01 – Cell Reference and Fluid Boundary Volumes
1 ≤ i ≤ NRAD, i is the radial ring number
1 ≤ jj ≤ NAXL, jj is the axial level number
Required

This record specifies a reference cell for defining missing input and the fluid control volume number(s) adjacent to cell ijj. Three fields are allowed; however, only the first needs to be present if it specifies a valid reference cell.

(1) IREFN - Reference cell (3-digit cell number)for setting values not input for this cell. Any input values that are missing from the input for this cell are set to the values for cell IREFN and no input error is generated. This field may be set to -1 if no reference cell is needed, but then all other input for this cell must be included.
(type = integer, default = -1, units = none)

(2) ICVHC - Channel control volume adjacent to this cell. This field may be missing or set to -1 if a valid cell is input for IREFN.
(type = integer, default = -1, units = none)

(3) ICVHB - Bypass control volume adjacent to this cell. This field is reserved for BWR calculations in which the interstitial volume between canister boxes must be modeled separately from the channel volume. This field may be missing or set to -1 if a valid cell is input for IREFN, and is ignored for PWR calculations (IRTYP = 'PWR').
(type = integer, default = -1, units = none)

CORijj02 – Cell Component Masses
1 ≤ i ≤NRAD, i is the radial ring number
1 ≤ jj ≤NAXL, jj is the axial level number
Optional if valid IREFN entered

This record and input record CORijj02A specify the initial masses of the intact components in cell ijj. The latter record is not permitted if IOLDOS=1 on input record COR00006. Neither record is required if a valid cell for IREFN has been entered on input record CORijj01. Eight floating point fields are allowed on this record; however, any of these fields may be missing or set to -1.1 if the value from reference cell IREFN is desired.

Equivalent information may optionally be provided, in a more general format, on input records CORijjKcc, where "cc" specifies a specific component.

(1) XMFU - Mass of UO2 in the cell fuel component.
(type = real, default = -1.1, units = kg)

(2) XMCL - Mass of Zircaloy in the cell cladding component.
(type = real, default = -1.1, units = kg)

(3) XMOS - Mass of steel in the cell OS component. Nonzero values are not permitted if IOLDOS=0 on input record COR00006, but a zero value may be required as a placeholder for nonzero entries in fields 5 through 8.
(type = real, default = -1.1, units = kg)

(4) XMCP - Mass of control poison in the cell OS "other structure" component. Nonzero values are not permitted if IOLDOS=0 on input record COR00006, but a zero value may be required as a placeholder for nonzero entries in fields 5 through 8.
(type = real, default = -1.1, units = kg)

(5) XMCN - Total mass of Zircaloy in the two cell canister components. Unless specified otherwise in sensitivity coefficient array 1501, the total canister mass entered in this field will be divided equally between the two canister components (one component is adjacent to the control blade, the other is not). This field is ignored for PWR calculations (IRTYP = 'PWR') if field six is not input.
(type = real, default = -1.1, units = kg)

(6) XMHT - Mass of electric heating element in the cell fuel component. If non-zero, a modified version of subroutine ELHEAT must be linked to MELCOR.
(type = real, default = -1.1, units = kg)

(7) XMIN - Mass of Inconel associated with the cell cladding component (e.g., PWR grid spacers).
(type = real, default = -1.1, units = kg)

(8) XMGT - Mass of Zircaloy associated with the cell "other structure" component (e.g., PWR control rod guide tubes).
(type = real, default = -1.1, units = kg)

CORijj02A – Additional Cell Component Masses
$1 \leq i \leq$ NRAD, i is the radial ring number
$1 \leq jj \leq$ NAXL, jj is the axial level number
Optional if valid IREFN entered

This record specifes the initial mass of intact supporting structure (SS) and nonsupporting structure (NS) components in cell ijj. It is permitted only if IOLDOS=0 on input record COR00006. Five floating point fields are allowed on this record; however, any of these fields may be missing or set to -1.1 if the value from reference cell IREFN is desired.

(1) XMSSSS - Mass of steel in cell supporting structure component.
(type = real, default = -1.1, units = kg)

(2) XMSSZR - Mass of Zircaloy in the cell supporting structure component.
(type = real, default = -1.1, units = kg)

(3) XMNSSS - Mass of steel in cell nonsupporting structure component.
(type = real, default = -1.1, units = kg)

(4) XMNSCP - Mass of control poison in the cell nonsupporting structure component.
(type = real, default = -1.1, units = kg)

(5) XMNSZR - Mass of Zircaloy in the cell nonsupporting structure component.
(type = real, default = -1.1, units = kg)

Instead of using record CORijj02 to input masses for the cell, optional input records for each component present in a cell may be used. Any given record is not generally required, but at least one mass value for at least one component must be entered if this option is exercised. For a given cell, the two options may not be mixed; use of the CORijj02 record precludes use of any of the new-format component mass records. However, different options may be used for different cells.

CORijjKFU – Fuel Component Masses
$1 \leq i \leq$ NRAD, i is the radial ring number
$1 \leq jj \leq$ NAXL, jj is the axial level number
Optional

This record specifies the initial masses of the fuel component in cell ijj. This record is not generally required, but component masses for at least one component must be entered if the new-format option is exercised for this cell. Two floating point fields are allowed on this record. If either field on this record is missing or set to -1.1 (or if the record is not present), the corresponding value from reference cell IREFN is used if IREFN is defined; otherwise the value is set to zero.

(1) XMFUUO - Mass of UO2 in the cell fuel component.
(type = real, default = -1.1, units = kg)

(2) XMFUHT - Mass of electric heating element in the cell fuel component. If non-zero, a modified version of subroutine ELHEAT must be linked to MELCOR.
(type = real, default = -1.1, units = kg)

CORijjKCL – Cladding Component Masses
$1 \leq i \leq$ NRAD, i is the radial ring number
$1 \leq jj \leq$ NAXL, jj is the axial level number
Optional

This record specifies the initial masses of the cladding component in cell ijj. This record is not generally required, but component masses for at least one component must be entered if the new-format option is exercised for this cell. Three floating point fields are allowed on this record. If any fields on this record are missing or set to -1.1 (or if the record is not present), the corresponding values from reference cell IREFN are used if IREFN is defined; otherwise the values are set to zero.

(1) XMCLZR - Mass of Zircaloy in the cell cladding component.
(type = real, default = -1.1, units = kg)

(2) XMCLIN - Mass of Inconel associated with the cell cladding component (e.g., PWR grid spacers).
(type = real, default = -1.1, units = kg)

(3) XMCLZX - Mass of ZrO_2 in the cell cladding component.
(type = real, default = -1.1, units = kg)

CORijjKCN – Canister (CN) Component Masses
$1 \leq i \leq$ NRAD, i is the radial ring number
$1 \leq jj \leq$ NAXL, jj is the axial level number
Optional

This record specifies the initial masses of the canister CN component (the portion not adjacent to a control blade) in cell ijj. This record is not generally required, but component masses for at least one component must be entered if the new-format option is exercised for this cell. Three floating point fields are allowed on this record. If any fields on this record are missing or set to -1.1 (or if the record is not present), the corresponding values from reference cell IREFN are used if IREFN is defined; otherwise the values are set to zero.

(1) XMCNZR - Mass of Zircaloy in the cell canister (CN) component.
(type = real, default = -1.1, units = kg)

(2) XMCNXI - Mass of ZrO_2 on the inside surface of the cell canister (CN) component.
(type = real, default = -1.1, units = kg)

(3) XMCNXO - Mass of ZrO_2 on the outside surface of the cell canister (CN) component.
(type = real, default = -1.1, units = kg)

CORijjKCB – Canister (CB) Component Masses
$1 \leq i \leq$ NRAD, i is the radial ring number
$1 \leq jj \leq$ NAXL, jj is the axial level number
Optional

This record specifies the initial masses of the canister CB component (the portion adjacent to a control blade) in cell ijj. This record is not generally required, but component masses for at least one component must be entered if the new-format option is exercised for this cell. Three floating point fields are allowed on this record. If any fields on this record are missing or set to -1.1 (or if the record is not present), the corresponding values from reference cell IREFN are used if IREFN is defined; otherwise the values are set to zero.

(1) XMCBZR - Mass of Zircaloy in the cell canister (CB) component.
(type = real, default = -1.1, units = kg)

(2) XMCBXI - Mass of ZrO_2 on the inside surface of the cell canister (CB) component.
(type = real, default = -1.1, units = kg)

(3) XMCBXO - Mass of ZrO_2 on the outside surface of the cell canister (CB) component.
(type = real, default = -1.1, units = kg)

CORijjKOS – "Other Structure" Component Masses
$1 \leq i \leq$ NRAD, i is the radial ring number
$1 \leq jj \leq$ NAXL, jj is the axial level number
Optional

This record specifies the initial masses of the OS "other structure" component in cell ijj, and is not permitted unless IOLDOS=1 on input record COR00006. Even then, it is not generally required, but component masses for at least one component must be entered if the new-format option is exercised for this cell. Five floating point fields are allowed on this record. If any fields on this record are missing or set to -1.1 (or if the record is not present), the corresponding values from reference cell IREFN are used if IREFN is defined; otherwise the values are set to zero.

(1) XMOSSS - Mass of steel in the cell "other structure" component.
(type = real, default = -1.1, units = kg)

(2) XMOSCP - Mass of control poison in the cell "other structure" component.
(type = real, default = -1.1, units = kg)

(3) XMOSZR - Mass of Zircaloy associated with the cell "other structure" component (e.g., PWR control rod guide tubes).
(type = real, default = -1.1, units = kg)

(4) XMOSSX - Mass of steel oxide in the cell "other structure" component.
(type = real, default = -1.1, units = kg)

(5) XMOSZX - Mass of ZrO_2 in the cell "other structure" component.
(type = real, default = -1.1, units = kg)

CORijjKSS – Supporting Structure Component Masses
$1 \leq i \leq$ NRAD, i is the radial ring number
$1 \leq jj \leq$ NAXL, jj is the axial level number
Optional

This record specifies the initial masses of the SS supporting structure component in cell ijj, and is not permitted if IOLDOS=1 on input record COR00006. This record is not generally required, but component masses for at least one component must be entered if the new-format option is exercised for this cell. Four floating point fields are allowed on this record. If any fields on this record are missing or set to

-1.1 (or if the record is not present), the corresponding values from reference cell IREFN are used if IREFN is defined; otherwise the values are set to zero.

(1) XMSSSS - Mass of steel in the cell supporting structure component.
(type = real, default = -1.1, units = kg)

(2) XMSSZR - Mass of Zircaloy in the cell supporting structure component.
(type = real, default = -1.1, units = kg)

(3) XMSSSX - Mass of steel oxide in the cell supporting structure component.
(type = real, default = -1.1, units = kg)

(4) XMSSZX - Mass of ZrO_2 in the cell supporting structure component.
(type = real, default = -1.1, units = kg)

CORijjKNS – Nonsupporting Structure Component Masses
$1 \leq i \leq$ NRAD, i is the radial ring number
$1 \leq jj \leq$ NAXL, jj is the axial level number
Optional

This record specifies the initial masses of the NS nonsupporting structure component in cell ijj, and is not permitted if IOLDOS=1 on input record COR00006. This record is not generally required, but component masses for at least one component must be entered if the new-format option is exercised for this cell. Four floating point fields are allowed on this record. If any fields on this record are missing or set to -1.1 (or if the record is not present), the corresponding values from reference cell IREFN are used if IREFN is defined; otherwise the values are set to zero.

(1) XMNSSS - Mass of steel in the cell nonsupporting structure component.
(type = real, default = -1.1, units = kg)

(2) XMNSCP - Mass of control poison in the cell nonsupporting structure component.
(type = real, default = -1.1, units = kg)

(3) XMNSZR - Mass of Zircaloy associated with the cell nonsupporting structure component (e.g., PWR control rod guide tubes).
(type = real, default = -1.1, units = kg)

(4) XMNSSX - Mass of steel oxide in the cell nonsupporting structure component.
(type = real, default = -1.1, units = kg)

(5) XMNSZX - Mass of ZrO_2 in the cell nonsupporting structure component.
(type = real, default = -1.1, units = kg)

CORijjKPD – Particulate Debris Component Masses
$1 \leq i \leq$ NRAD, i is the radial ring number
$1 \leq jj \leq$ NAXL, jj is the axial level number
Optional

This record specifies the initial masses of the particulate debris component in cell ijj. For a cell with a separate bypass region in a BWR, it is the mass in the channel region, and mass in the bypass region is entered on the CORijjKPB record. This record is not generally required, but component masses for at least one component must be entered if the new-format option is exercised for this cell. Seven floating point fields are allowed on this record. If any fields on this record are missing or set to -1.1 (or if the record is not present), the corresponding values from reference cell IREFN are used if IREFN is defined; otherwise the values are set to zero.

(1) XMPDUO - Mass of UO_2 in the cell particulate debris component.
(type = real, default = -1.1, units = kg)

(2) XMPDZR - Mass of Zircaloy in the cell particulate debris component.
(type = real, default = -1.1, units = kg)

(3) XMPDZX - Mass of ZrO_2 in the cell particulate debris component.
(type = real, default = -1.1, units = kg)

(4) XMPDSS - Mass of steel in the cell particulate debris component.
(type = real, default = -1.1, units = kg)

(5) XMPDSX - Mass of steel oxide in the cell particulate debris component.
(type = real, default = -1.1, units = kg)

(6) XMPDCP - Mass of control poison in the cell particulate debris component.
(type = real, default = -1.1, units = kg)

(7) XMPDIN - Mass of Inconel in the cell particulate debris component.
(type = real, default = -1.1, units = kg)

CORijjKPB – Particulate Debris Component Masses in Bypass
$1 \leq i \leq$ NRAD, i is the radial ring number
$1 \leq jj \leq$ NAXL, jj is the axial level number
Optional

This record specifies the initial masses of the particulate debris component in the bypass of cell ijj. This record is not generally required, but component masses for at least one component must be entered if the new-format option is exercised for this cell. Seven floating point fields are allowed on this record. If any fields on this record are missing or set to -1.1 (or if the record is not present), the corresponding values from reference cell IREFN are used if IREFN is defined; otherwise the values are set to zero.

(1) XMPBUO - Mass of UO_2 in the cell bypass particulate debris component.
(type = real, default = -1.1, units = kg)

(2) XMPBZR - Mass of Zircaloy in the cell bypass particulate debris component.
(type = real, default = -1.1, units = kg)

(3) XMPBZX - Mass of ZrO_2 in the cell bypass particulate debris component.
(type = real, default = -1.1, units = kg)

(4) XMPBSS - Mass of steel in the cell bypass particulate debris component.
(type = real, default = -1.1, units = kg)

(5) XMPBSX - Mass of steel oxide in the cell bypass particulate debris component.
(type = real, default = -1.1, units = kg)

(6) XMPBCP - Mass of control poison in the cell bypass particulate debris component.
(type = real, default = -1.1, units = kg)

(7) XMPBIN - Mass of Inconel in the cell bypass particulate debris component.
(type = real, default = -1.1, units = kg)

CORijjYcc – Conglomerate Debris Masses

$1 \leq i \leq$ NRAD, i is the radial ring number
$1 \leq jj \leq$ NAXL, jj is the axial level number
cc is the component identifier (any component permitted by the value of IOLDOS on input record COR00006 except FU)
Optional

This record specifies the initial conglomerate debris masses for component cc in cell ijj. This record is not required. Seven floating point fields are allowed on this record. If any fields on this record are missing or set to -1.1 (or if the record is not present), the corresponding values from reference cell IREFN are used if IREFN is defined; otherwise the values are set to zero.

(1) YMCCUO - Mass of UO_2 in the conglomerate debris for component cc.
(type = real, default = -1.1, units = kg)

(2) YMCCZR - Mass of Zircaloy in the conglomerate debris for component cc.
(type = real, default = -1.1, units = kg)

(3) YMCCZX - Mass of ZrO_2 in the conglomerate debris for component cc.
(type = real, default = -1.1, units = kg)

(4) YMCCSS - Mass of steel in the conglomerate debris for component cc.
(type = real, default = -1.1, units = kg)

(5) YMCCSX - Mass of steel oxide in the conglomerate debris for component cc.
(type = real, default = -1.1, units = kg)

(6) YMCCCP - Mass of control poison in the conglomerate debris for component cc.
(type = real, default = -1.1, units = kg)

(7) YMCCIN - Mass of Inconel in the conglomerate debris for component cc.
(type = real, default = -1.1, units = kg)

CORijj03 – Cell Initial Temperature
$1 \leq i \leq$ NRAD, i is the radial ring number
$1 \leq jj \leq$ NAXL, jj is the axial level number
Optional if valid IREFN entered

This record specifies the initial component temperatures for cell ijj. This record is not required if a valid cell for IREFN has been entered. Nine floating point fields are allowed on this record; however, any of these fields may be missing or set to -1.1 if the value from reference cell IREFN is desired.

(1) TFU - UO_2 fuel temperature.
(type = real, default = -1.1, units = K)

(2) TCL - Cladding temperature.
(type = real, default = -1.1, units = K)

(3) TOS - OS "other structure" temperature.
(type = real, default = -1.1, units = K)

(4) TCN - Canister (CN) temperature. This field is ignored for PWR calculations (IRTYP = 'PWR').
(type = real, default = -1.1, units = K)

(5) TCB - Canister (CB) temperature. If omitted, the CB component will be initialized to the CN component temperature entered on the fourth field. This field is ignored for PWR calculations (IRTYP = 'PWR'). (type = real, default = -1.1, units = K)

(6) TPD - Particulate debris temperature. If omitted, the value from reference cell IREFN is used if IREFN is defined; otherwise the value is set to zero. (type = real, default = -1.1, units = K)

(7) TSS - Supporting structure temperature. (type = real, default = -1.1, units = K)

(8) TNS - Nonsupporting structure temperature. (type = real, default = -1.1, units = K)

(9) TPB - Particulate debris temperature in the bypass. If omitted, the value from reference cell IREFN is used if IREFN is defined; otherwise the value is set to zero. (type = real, default = -1.1, units = K)

CORijj04 – Equivalent Diameter Record
$1 \leq i \leq$ NRAD, i is the radial ring number
$1 \leq jj \leq$ NAXL, jj is the axial level number
Optional if valid IREFN entered

This record specifies the equivalent diameter (for convective heat transfer) for each component in cell ijj. This record is not required if a valid cell for IREFN has been entered. Eight floating point fields are allowed on this record; however, any of these fields may be missing or set to -1.1 if the value from reference cell IREFN is desired.

(1) DHYCL - Cladding equivalent outside diameter. (type = real, default = -1.1, units = m)

(2) DHYOS - OS "other structure" equivalent diameter. (type = real, default = -1.1, units = m)

(3) DHYPD - Particulate debris equivalent diameter. Because it is used in calculating total debris surface area, this diameter is of particular importance in calculating quenching heat transfer during material relocation from the core to the lower plenum in the falling debris quench model. If desired, a different value can be specified as DHYPB for debris in the bypass of a BWR.

(type = real, default = -1.1, units = m)

(4) DHYCNC - Canister inside equivalent diameter. The same value is used for both canister components. This field is ignored for PWR calculations (IRTYP = 'PWR').
(type = real, default = -1.1, units = m)

(5) DHYCNB - Canister outside equivalent diameter. Currently, the same value is used for both canister components (i.e., the fact that one canister component is adjacent to the control blade and the other is not is not taken into account). This field is ignored for PWR calculations (IRTYP = 'PWR').
(type = real, default = -1.1, units = m)

(6) DHYSS - Supporting structure equivalent diameter.
(type = real, default = -1.1, units = m)

(7) DHYNS - Nonsupporting structure equivalent diameter.
(type = real, default = -1.1, units = m)

(8) DHYPB - Particulate debris equivalent diameter in the bypass of a BWR. If this field is omitted, the diameter of particulate debris in the channel will be used.
(type = real, default = DHYPD, units = m)

CORijj05 – Cell Boundary and Flow Areas Record
$1 \leq i \leq$ NRAD, i is the radial ring number
$1 \leq jj \leq$ NAXL, jj is the axial level number
Optional if valid IREFN entered

This record specifies the outer radial boundary area and the intact cross-sectional flow areas for cell ijj. The flow areas will be automatically reduced to account for any debris masses present in the cell. This record is not required if a valid cell for IREFN has been entered. Three floating point fields are allowed on this record; however, any of these fields may be missing or set to -1.1 if the value from reference cell IREFN is desired.

(1) ASCELR - Area of outer radial cell boundary ($2\pi R \cdot DZ$, where R is the outer radius of ring i and DZ is the axial level length of level jj).
(type = real, default = -1.1, units = m^2)

(2) AFLOWC - Channel flow area of cell.
(type = real, default = -1.1, units = m^2)

(3) AFLOWB - Bypass flow area of cell in a BWR. For a PWR, AFLOWB will simply be added to AFLOWC.
(type = real, default = -1.1, units = m^2)

CORijj06 – Surface Area Record
$1 \leq i \leq$ NRAD, i is the radial ring number
$1 \leq jj \leq$ NAXL, jj is the axial level number
Optional if valid IREFN entered

This record specifies the intact surface area for each intact component in cell ijj. These areas will be automatically adjusted to account for any debris masses present in the cell. This record is not required if a valid cell for IREFN has been entered. Four floating point fields are allowed on this record; however, any of these fields may be missing or set to -1.1 if the value from reference cell IREFN is desired.

(1) ASFU - Fuel surface area.
(type = real, default = -1.1, units = m^2)

(2) ASCL - Cladding surface area.
(type = real, default = -1.1, units = m^2)

(3) ASOS - OS "other structure" surface area.
(type = real, default = -1.1, units = m^2)

(4) ASCN - Total canister inside surface area. The value entered in this field will be divided equally between the two canister components, unless specified otherwise in sensitivity coefficient array 1501. This field is ignored for PWR calculations (IRTYP = 'PWR')
(type = real, default = -1.1, units = m^2)

(5) ASSS - Supporting structure surface area.
(type = real, default = -1.1, units = m^2)

(6) ASNS - Nonsupporting structure surface area.
(type = real, default = -1.1, units = m^2)

CORijj07 – Oxidation Shutoff and Structure Failure Control Function Record
$1 \leq i \leq$ NRAD, i is the radial ring number
$1 \leq jj \leq$ NAXL, jj is the axial level number
Optional

This record specifies LOGICAL control functions to control various models on a cell by cell basis. A value of 0 indicates that no control function is to be used. If this

record is absent, values default to those for reference cell IREFN, if it is defined, or to 0. One or two integer fields are allowed on this record; a value of -1 indicates that the value from the reference cell is to be used.

(1) ICFNOX - Oxidation shutoff control function. A control function value of .TRUE. will shut off oxidation in cell ijj (e.g., to model the effects of a flow blockage) for all surfaces connected to the channel control volume (ICVHC on record CORijj01).
(type = real, default = 0 or -1, units = none)

(2) ICFLSF - Structure failure control function, used for other structure OS only. A control function value of .TRUE. will cause the "tens" digit of the particulate debris support flag ISUP in cell ijj to be reset to zero, thus eliminating support of any debris by "other structure."
(type = real, default = 0 or -1, units = none)

CORijjDX – Particulate Debris Exclusion Parameters in Single Cell
$1 \leq i \leq$ NRAD, i is the radial ring number
$1 \leq jj \leq$ NAXL, jj is the axial level number
Optional

These records may be used to override the previous definition of particulate debris exclusion parameters for individual core cells. The format and options are identical to those for the COR000DX input record.

CORijjNS – Support Rule for NS in Single Cell
$1 \leq i \leq$ NRAD, i is the radial ring number
$1 \leq jj \leq$ NAXL, jj is the axial level number
Optional

These records may be used to override the previous definition of support of NS for individual core cells. The format and options are identical to those for the COR000NS input record with the exception that the 'BLADE' and 'ROD' options are not available because the input affects only a single axial level of the core.

CORijjSS – Loading and Failure Rule for SS in Single Cell
$1 \leq i \leq$ NRAD, i is the radial ring number
$1 \leq jj \leq$ NAXL, jj is the axial level number
Optional

These records may be used to override the previous definition of modeling of SS for individual core cells. The format and options are identical to those for the COR000SS input record.

CORRiiPC – Pool Heat Transfer from Bottom/Top of SS Plates in Radial Ring
$1 \leq i \leq$ NRAD, i is the radial ring number
$1 \leq jj \leq$ NAXL, jj is the axial level number
Optional

These records may be used to override the global (or default) definition of modeling of heat transfer from SS plate surfaces for individual core cells. The format and options are identical to those for the COR000PC input record.

CORRiiPR –Downward Radiation from SS to Pool or Lower Head in Radial Ring
$1 \leq i \leq$ NRAD, i is the radial ring number
$1 \leq jj \leq$ NAXL, jj is the axial level number
Optional

These records may be used to override the global (or default) definition of modeling of downward radiation from SS for individual core cells. The format and options are identical to those for the COR000PR input record.

2.5 MELGEN Lower Head Input

CORLHDii – Lower Head Structure Record
$01 \leq ii \leq$ NRAD, ii is the radial ring number
Required

Each record specifies information for one lower head radial ring; a total of NRAD of these records are required, one for each ring. For a description on how these parameters are used in the lower head model, see the COR Package Reference Manual, Section 5.1. Note that the value of RADLH for ii=NRAD should be equal to the inner radius of the lower head hemispherical shell (which is also equal to the inner radius of the cylindrical reactor vessel); for all other rings, it should match the value implied by entry ASCELA on input record CORRii01.

(1) IRS - Starting ring number. This field must be set to 1 on the first lower head record, and must be equal to IRE+1 from the preceding lower head record for each succeeding lower head record. (type = integer, default = none, units = none)

(2) IRE - Ending ring number. Must be input equal to IRS. The option of defining more than one ring at a time is not currently available, but the input is retained for possible future expansion. (type = integer, default = none, units = none)

(3) TLH - Initial temperature of lower head nodes in radial ring ii.
(type = real, default = none, units = K)

(4) RADLH - Outer radius of radial ring ii, used to calculate the surface area and inclination angle for the lower head.
(type = real, default = none, units = m)

(5) ICVCAV - Reactor cavity control volume number. This field need only be input for the first lower head record.
(type = integer, default = none)

CORLHNnn – Lower Head Nodalization Record
$1 \leq nn \leq NLH-1$, nn is a sequencing identifier for the lower head mesh layers
Optional

These optional records are used to define the mesh nodalization and composition in the lower head. If these records are absent, the lower head will consist of NLH-1 mesh layers of carbon steel, which are all of thickness DZLH/(NLH-1). If these records are included, then all the lower head mesh layers (from 1 to NLH-1) must be described beginning from the inner surface of the lower head to the outer surface. Each record contains one or more data pairs describing an individual mesh layer, and there must be a total of NLH-1 data pairs included. The final value of DZLP must be equal to DZLH from record COR00001. If a material defined by these records is not included in the Materials Properties (MP) package data base or if the MP data base does not contain all of the required properties for a default material, then the user must provide MP input for the required properties, which are: thermal conductivity, specific heat, density, enthalpy vs. temperature, temperature vs. enthalpy, melt temperature and latent heat of fusion for the material. For a description on how these parameters are used in the lower head model, see the COR Package Reference Manual, Section 4.1. Each data pair consists of:

(1) MATNAM - Material name from the MP package data base or a user-defined material.
(type = character*24, default = none, units = none)

(2) DZLP - Distance from inner surface of lower head to outer boundary of this particular mesh layer. The last value of DZLP must be equal to DZLH from record COR00001.
(type = real, default = none, units = m)

CORPENnn – Lower Head Penetration Record
01 ≤ nn ≤ NPNTOT, nn is the penetration number
Required if NPNTOT > 0

This record specifies information for representative lower head penetration nn. For a description on how these parameters are used in the lower head model, see the COR Package Reference Manual, Sections 5.1 and 5.2. This record must be input for each representative penetration from 1 to NPNTOT (input on record COR00000). No more than three penetrations may be defined in any radial ring. This is sufficient to define distinct models for instrumentation tubes, control rod guide tubes, and drain plugs. If the first field specifies a valid reference penetration, only the second field, specifying the radial ring number, will be processed. If the first field does not specify a valid reference penetration, all the remaining fields must be present. Total values for all structures represented by this penetration should be supplied.

(1) IPNREF - Reference penetration number. IPNREF must be less than nn. Enter -1 if no reference penetration is needed.
(type = integer, default = none, units = none)

(2) IRP - Radial ring where this representative penetration is located. The value of IRP on this record must be greater than or equal to the value of IRP entered on the previous penetration record.
(type = integer, default = none, units = none)

(3) XMPN - Total mass of structures represented by this penetration.
(type = real, default = none, units = kg)

(4) TPN - Initial temperature of representative penetration.
(type = real, default = none, units = K)

(5) ASPN - Total surface area of structures represented by this penetration, based on the height DZ of the bottom axial level. The area of contact with debris is calculated from ASPN based on the debris height.
(type = real, default = none, units = m^2)

(6) AXPN - Total effective conduction area of structures represented by this penetration at junction with the lower head, used to control heat transfer between head and penetration.
(type = real, default = none, units = m^2)

(7) DFLPN - Initial diameter of failure opening for ejection of molten core materials (may represent single or multiple tube failures).
(type = real, default = none, units = m)

2.6 MELGEN COR Material Input

CORMATx – Core Material Specification Record
x can be any alphanumeric character
Optional

The materials to be used for "control rod poison" and "electric heater rod material" may be specified on the COR00002 input record. These optional records allow the user to redefine the properties to be used for other materials in the COR package. Only the thermal equation of state (including melting point and heat of fusion), density, thermal conductivity, and–for steel–composition will be used. The intention is to allow redefinition of properties without affecting the properties of default materials that may be used in other packages, particularly in HS. Substitution of materials will have no effect on chemical properties assumed for the materials in the oxidation or eutectics models or on any properties used for them in the FDI or CAV packages.

(1) CORMAT - Identifier for "material" in the COR package. Permitted values are 'UO2', 'ZR', 'ZRO2', 'SS', and 'SSOX'.
(type = character*2, default = none, units = none)

(2) MATNAM - Material name from the MP package data base or a user-defined material whose properties are to be used for the designated COR material.
(type = character*24, default = none, units = none)

In the absence of input on CORMATx records, the properties used will be those of default materials in the MP package: 'URANIUM DIOXIDE' for 'UO2', 'ZIRCALOY' for 'ZR', 'ZIRCONIUM DIOXIDE' for 'ZRO2', 'STAINLESS STEEL' for 'SS', and 'STAINLESS STEEL OXIDE' for 'SSOX'.

2.7 MELGEN CVH Fluid Flow Interface Input

CORTINxx – Inlet Temperature Specification Record
xx can be anything
Permitted only if IDTDZ = 1 on record COR00006.

If IDTDZ = 1:
Required for top and bottom volumes containing core cells

Optional for all other control volumes

This record allows the user to specify an inlet temperature boundary condition for the dT/dz model that differs from the default modeling. For details on this model, see the COR Package Reference Manual, Section 2.5. If IDTDZ = 1 on record COR00006, a CORTIN record is required for every hydrodynamic control volume that 1) contains the lowest or highest axial core cells *or* 2) is directly above or below a control volume in which dT/dz calculations are disabled by some other CORTIN record. The record is optional for all other control volumes containing core cells.

(1) IVOL - Core control volume number.
(type = integer, default = none, units = none)

(2) ITUP - Inlet temperature specification for volume IVOL for upflow.
= 0 Use exit temperature for next lower control volume. (This is the default for all volumes not appearing on CORTIN records.)
= 1000 Disable dT/dz model for this volume
= 2000 Use the model employed for IDTDZ = 0. (Must also specify ITDN = 2000.)
> 0 Use temperature of volume ITUP $\leq$ 999.
< 0 Use value of control function -ITUP $\leq$ 999.
(type = integer, default = 0, units = none)

(3) ITDN - Inlet temperature specification for volume IVOL for downflow.
= 0 Use exit temperature for next higher control volume. (This is the default for all volumes not appearing on CORTIN records.)
Other options are the same as for ITUP.
(type = integer, default = 0, units = none)

CORVOLxxx – Ring Flow Area Control Functions
xxx can be any three digit integer
Optional

This optional record identifies the control functions (ICFVOL) that may be used in the COR oxidation model to define the flow areas associated with each COR ring within CVH volumes interfaced with the COR package. The ring flow areas are used solely to allocate steam and oxygen from the CVH volumes to the various rings modeled by the COR package.

As specified on input record COR00000, the core is partitioned into NRAD rings, and interfaced with NCVOL CVH volumes. Each CORVOLxxx record defines

NRAD control functions for a single identified control volume. There may be as many as NCVOL such records, each containing NRAD+1 entries:

(1) IVOL- - The CVH control volume number for which the control functions on this record apply.
(type = integer, default = none, units = none)

(2) ICFVOL(1)
- The number of the REAL control function from which the unblocked flow area of ring 1 is to be obtained.
(type = integer, default = none, units = none)

(3) ICFVOL(2)
- The number of the REAL control function from which the unblocked flow area of ring 2 is to be obtained.
(type = integer, default = none, units = none)

ICFVOL(NRAD+1)
- The number of the REAL control function from which the unblocked flow area of ring NRAD is to be obtained.
(type = integer, default = none, units = none)

The default calculation of unblocked flow area in any ring may be retained by entering 0 in the corresponding field. An entry of 0 is required for the flow area of any core ring with which volume ICVOL does not interface. (In general, a core CVH control volume need not be interfaced with all rings of the core.)

2.8 MELCOR Input

Records COR00003 through COR00005, COR00007 through COR00009, and record COR00012 described in Section 2.1 may also be included in MELCOR input for any restart. These records input basic modeling parameters for the COR package and it is desirable to have the capacity to vary these parameters for testing purposes and perhaps some sensitivity analyses. However, the user should be aware that changing these parameters in the middle of a calculation could lead to nonphysical results.

Additional records that may be input for the COR package for a MELCOR restart run are concerned with time step control, package edit control, and physics module disabling, and are described below.

CORDTC01 – COR Package Time Step Control Record
Optional

This record allows the user to specify certain quantities needed to control the COR package internal time step. This record is not required, but if included, two floating point fields and one integer field must be present.

(1) DTMPCR - Maximum allowed temperature increase of a component during a COR package time step. This maximum is applied only to components with total mass greater than the minimum specified in sensitivity coefficient array 1502.
(type = real, default = 30.0, units = K)

(2) DTCMIN - Minimum COR package time step allowed.
(type = real, default = 0.001, units = s)

(3) NSUBMX - Maximum number of COR package subcycles during a single system cycle.
(type = integer, default = 64, units = none)

COREDV01 – Edit Flags Record
Optional

This record specifies edit flags which allow the user to control what variables from the COR package are edited to the print output file. This record is not required, and if present, any number of flags may be present, up to 6. The flag for a particular edit block should be set to 1 if printing of that block is desired, and to 0 if not.

(1) ITEMP - Temperature edit flag.
(type = integer, default = 1, units = none)

(2) IMASS - Mass edit flag.
(type = integer, default = 1, units = none)

(3) IVOL - Volume edit flag.
(type = integer, default = 0, units = none)

(4) IASUR - Surface area edit flag
(type = integer, default = 0, units = none)

(5) IPMV - Component masses and volume fractions plot flag
(type = integer, default = 0, units = none)

(6) IPOW - Decay heat/fission power edit flag
(type = integer, default = 0, units = none)

CORTST01 – Physics On/Off Switches
Optional

This record specifies switches that allow the user to disable portions of the COR package physics for purposes of debugging or testing of new physics modules. This record is not required, and any number of integer fields may be present, up to 10. Set these switches to 1 to disable a particular model, and to 0 to re-enable.

(1) IRAD - Disable switch for radiation model, including radiation to steam, (regardless of the value of switch number 8).
(type = integer, default = 0, units = none)

(2) ICND - Disable switch for conduction model.
(type = integer, default = 0, units = none)

(3) ICNV - Disable switch for convection model.
(type = integer, default = 0, units = none)

(4) IOXD - Disable switch for all oxidation models, including the B_4C reaction (regardless of the value of switch number 7).
(type = integer, default = 0, units = none)

NOTE: There are two oxidation options: the default option for hierarchical treatment in which steam oxidation does not begin until all oxygen has been consumed, and an option for treating oxidation by oxygen and steam simultaneously. Furthermore, oxidation of the conglomerate debris may be deactivated without deactivating the oxidation of intact components. The following values of IOXD may be specified:
0 - (default) hierarchical option for both intact components and conglomerate debris,
1 - no oxidation of either intact components or conglomerate debris,
2 - hierarchical option for intact components with no conglomerate debris oxidation,
3 - simultaneous option for both intact components and conglomerate debris, and
4 - simultaneous option for intact components with no conglomerate debris oxidation.

(5) IDRP - Disable switch for candling model
(type = integer, default = 0, units = none)

NOTE: A value of IDRP=1 completely disables the candling model while a value of IDRP=2 disables only the melt holdup model.

(6) ITDZ - Disable switch for core dT/dz model.
(type = integer, default = 0, units = none)

(7) IB4C - Disable switch for B_4C reaction model, if not already disabled by switch 4.
(type = integer, default = 0, units = none)

(8) IRDS - Disable switch for radiation to steam model, if not already disabled by switch 1.
(type = integer, default = 0, units = none)

(9) IDEJ - Disable switch for solid debris ejection model.
(type = integer, default = 0, units = none)

(10) ISPR - Disable switch for radial relocation model.
(type = integer, default = 0, units = none)

NOTE: A value of ISPR=1 disables only the molten material radial relocation; a value of ISPR=2 disables only the particulate debris radial relocation model; and a value of ISPR=3 disables both radial relocation models.

2.9 Required Input to Other MELCOR Packages

Many of the models in the COR package require that it interface with other MELCOR packages. Thus, in order for the COR package to function properly, input may be required in other packages to complete these interfaces. This section outlines these input requirements for the Control Volume Hydrodynamics (CVH), Flow Path (FL), NonCondensible Gas (NCG), Control Function (CF), Decay Heat (DCH), Radionuclide (RN) and Heat Structure (HS) packages. The user is referred to the appropriate Users' Guides and Reference Manuals for further details regarding these packages.

2.9.1 CVH, FL, and NCG Input

The COR package models heat transfer between core structures and the liquids and/or gases which flow through the core. These flows are modeled by the CVH and FL packages. The user must specify a control volume for the coolant channel (and for the bypass for BWRs) in each core cell in order for that cell to communicate heat transfer

information. This is done through COR input records CORijj01, as described in Section 0. Each control volume referenced on these records must be defined in the CVH input. The control volumes must be interconnected by flow paths that are defined through input to FL. COR only checks that each control volume referenced by COR input exists. The user is responsible for providing CVH and FL input that is reasonable, logical, and above all, consistent with the physical realities of the core geometry to be modeled.

Some degree of consistency is required between the distribution of fluid volumes implied by input to COR and CVH. The specific requirement is that the initial total fluid volume in COR lying within any Volume/Altitude segment of a CVH control volume cannot exceed the fluid volume in that V/A segment, so that filling the entire fluid volume in COR with debris cannot overfill CVH. This requirement is new in MELCOR 1.8.5 See section 1.5.3 for suggestions on revising old input decks to comply.

Another COR input, which is found on record CORTINxx, is indirectly related to CVH and FL in that it is used to determine the inlet temperature to the core whenever the dT/dz model is used to estimate local hydrodynamic temperatures within the core. The user must ensure that any control volume or control function referenced by these records exists in the CVH or CF input.

If the user desires to perform detailed natural circulation calculations using the CVH and FL packages, one CVH control volume should be specified for a relatively small number of core cells (perhaps only one cell per volume). The core flow blockage and momentum flux models should be enabled for all flow paths involving core cells, as described in the Flow Path Package Users' Guide (input records FLnnnBk and FLnnnMk). Note that new blockage options, including a channel box model, are available in MELCOR 1.8.5. The dT/dz model should not be disabled in these flowpaths. Radial flow paths may be used in PWRs, and channel-to-bypass flow paths in BWRs. There will probably be some penalty in increased CPU time resulting from the need to invert a substantially larger flow matrix. However, use of the blockage model has been found to largely eliminate the further penalty that would otherwise be associated with reduced material Courant time step limits when control volumes are almost completely filled with core debris.

Hydrogen and carbon monoxide must be specified as active materials in the NCG package whenever the COR package is active due to the generation of these gases in the COR oxidation models. In addition, for calculations with B_4C used as the control poison material, the gases O_2, CO_2 and CH_4 must also be specified as active materials via NCG input, since they are produced by the B_4C reaction model.

2.9.2 DCH and RN Input

The COR package distributes the decay heat generated by the fission products and, if applicable, the fission energy, to the core components. The properties of the time-dependent decay heat distribution are specified through input to both the DCH and RN

packages. The fission power is specified in the COR package through the use of a control function.

The total core decay heat is set up through input to the DCH package. In general, the user specifies the type of reactor to be modeled, the problem time at which the reactor shut down, the power level at which the reactor was operating, and the type of decay heat correlation to be used.

The decay heat is distributed among the core cells in different ways depending on whether or not the RN package is active. If the RN package is not active, the energy is distributed along with any fission power according to the axial and radial power density profiles specified on records CORZjj03 and CORRii03, respectively.

When the RN package is active, the decay heat is distributed throughout MELCOR in proportion to the radionuclide distribution as determined by the RN package. The user must specify the initial distribution of radionuclides to RN through the use of the RN package input records described in Section 3.1.2 of the RN Package Users' Guide. If these records are not used, no decay heat whatsoever may be passed to the core.

In Anticipated Transient Without SCRAM (ATWS) calculations or other problems involving fission heating, whole-core fission power may be calculated using a control function specified on record COR00004, which must be set up through input to the CF package. The power is distributed (and added to decay heat) in the COR package according to the axial and radial power density profiles specified on records CORZjj03 and CORRii03, respectively.

Furthermore, if the advanced B_4C reaction model is invoked, seven additional Radionuclide (RN) package classes must be defined to treat the additional reaction products generated by the model (see example input in Section 5.1).

2.9.3 HS Input

The COR package requires boundary heat structures to be specified in order to calculate the energy radiated from the COR cells. These heat structures must be set up through appropriate input to HS, and their existence is checked by the COR package in MELGEN. For the dT/dz model to function properly, **there must be exactly one heat structure per axial level**; otherwise the effect of these heat structures on the control volume temperature distribution will not be treated correctly. Also, no other heat structures may communicate with the core and lower plenum control volumes other than those specified on the CORZjj02 input record. Furthermore, for the dT/dz model to function correctly and for the HS package to model the heat transfer appropriately, it is important that the heat structures representing the radial core boundary (e.g., core shroud) communicate with the temperatures calculated by the dT/dz model. The outer ring core cells must therefore be

specified as the fluid temperature boundary on input records HSCCCCC004 (see the HS Package Users' Guide) unless the IHSDT option switch provided on input record COR00006 has been set to 1.

Melting of these boundary heat structures may be modeled using HSDGCCCCCn input records. As any such structure melts, the molten steel will be added to core debris in the adjoining core cell. That cell is not specified directly as part of HS input, but is inferred from the elevation of the heat structure; structures above the top of the core deliver their steel to the outermost ring of the uppermost level of the core.

2.9.4 MP Input

The COR package obtains materials properties from the Materials Properties (MP) package. In addition to general consistency of the various tables and constant properties defining the thermal equation of state, the COR package assumes that the melting range of any pure material spans exactly 0.01K. This is true for all default materials in the MP package, as noted in the introductory paragraphs of Section 2 of the MP Reference Manual.

However, if the properties of a default material used by core are modified, or if a user-defined material is specified to represent a core material, it is essential that the 0.01 K melting range be preserved. A user-defined material may be input either as the electric heating element material, MATHT, on the COR00002 input record, or as a substitute for one of the other core materials, as MATNAM on a CORMATx input record.

3. Sensitivity Coefficients

This section lists the sensitivity coefficients in the COR package that are accessible to the user, along with a brief description, and gives their default values, units, and EQUIVALENCE names. Sensitivity coefficients in the COR package are grouped as follows:

1001 – 1299 oxidation and heat transfer parameters
1301 – 1399 fission power parameters
1401 – 1499 numerical control parameters
1501 – 1599 geometric parameters
1600 – 1699 lower-head mechanical model parameters

More details are given in the COR Package Reference Manual on the usage of these coefficients in the models where they are applied and the basis for their default values.

3.1 Oxidation, Heat Transfer, and Relocation Parameters

1001 – Zircaloy Oxidation Rate Constant Coefficients

These coefficients are used to calculate the rate constant for oxidation of Zircaloy by parabolic kinetics. The rate constant K (kg^2/m^4-s) as a function of temperature T (K) is calculated by:

$$K(T) = C1001(1,I)\exp(-C1001(2,I)/T), T \le C1001(5,I)$$

$$K(T) = C1001(3,I)\exp(-C1001(4,I)/T), T \ge C1001(6,I)$$

where I=1 for oxidation by H_2O and I=2 for oxidation by O_2. An interpolated value is used in the temperature range C1001(5,I) < T < C1001(6,I).

(1,I) - low temperature range constant coefficient
(default = 29.6 for I=1, 50.4 for I=2; units = kg^2(Zr)/m^4-s, equiv = none)

(2,I) - low temperature range exponential constant
(default = 16820.0 for I=1, 14630.0 for I=2; units = K, equiv = none)

(3,I) - high temperature range constant coefficient
(default = 87.9 for I=1, 0.0 for I=2; units = kg^2(Zr)/m^4-s, equiv = none)

(4,I) - high temperature range exponential constant
(default = 16610.0 for I=1, 0.0 for I=2; units = K, equiv = none)

(5,I) - upper temperature boundary for low temperature range
(default = 1853.0 for I=1, 10000.0 for I=2; units = K, equiv = none)

(6,I) - lower temperature boundary for high temperature range
(default = 1873.0 for I=1, 10000.0 for I=2; units = K, equiv = none)

1002 – Steel Oxidation Rate Constant Coefficients

These coefficients are used to calculate the rate constant for oxidation of steel by parabolic kinetics. The rate constant K (kg^2/m^4-s) as a function of temperature T (K) is calculated by:

$$K(T) = C1002(1,I)\exp[-C1002(2,I)/T]$$

where I=1 for oxidation by H_2O and I=2 for oxidation by O_2. No oxidation of steel by O_2 is calculated.

(1,*I*) - constant coefficient
(default = 2.42E09 for *I*=1, 0.0 for *I*=2; units = kg^2(steel)/m^4-s, equiv = none)

(2,*I*) - exponential constant
(default = 4.24E04 for *I*=1, 0.0 for *I*=2; units = K, equiv = none)

1003 – Gaseous Diffusion Oxidation Coefficients

These coefficients are used to calculate the oxidation rate for Zircaloy and steel based on the gaseous diffusion of steam through hydrogen to the metal surface. The following equation gives the oxidation rate W (kg/s) in terms of the mass transfer coefficient k_c (m/s), the metal surface area A (m^2), the difference in oxidant partial pressure between the bulk gas and the surfaceΔ ΔP_{ox} (Pa), the film temperature T_f (K), and the sensitivity coefficient C1003(m):

$$W = k_c A \Delta P_{ox} C1003(m) / T_f,$$

where C1003(m) is defined in terms of the universal gas constant R, the molecular weight of the metal M_m, and the number of moles of steam to oxidize one mole of metal n_m:

$$C1003(m) = M_m / (n_m \cdot R)$$

The default values may be changed to selectively increase or decrease the gaseous diffusion based oxidation rate.

(1) - Zircaloy constant.
(default = 0.00548, units = kg(Zr)-K/Pa-m^3, equiv = none)

(2) - Steel constant.
(default = 0.00504, units = kg(steel)-K/Pa-m^3, equiv = none)

1004 – Oxidation Cutoff Temperatures

These coefficients are used to prevent Zircaloy and steel oxidation below or above certain temperatures. The lower cutoff temperature prevents oxidation at temperatures that generate only minute quantities of noncondensible gases. The

upper cutoff temperature can be used to limit the amount of oxidation for sensitivity analyses.

(1) - Minimum oxidation temperature
(default = 1100.0, units = K, equiv = none)

(2) - Maximum oxidation temperature
(default = 9900.0, units = K, equiv = none)

1005 – B_4C Reaction Model Parameters

These coefficients are used to select and control the simple or advanced B_4C reaction model. If reducing environments are expected (significant hydrogen concentrations), then the advanced model should be selected and the user should refer to Section 5.1 for an example of the additional required RN and DCH input.

(1) - Model selection switch (0./1. for simple/advanced model)
(default = 0.0, units = none, equiv = none)

(2) - Maximum B_4C fraction that may be consumed by the reaction model
(default = 0.02, units = none, equiv = none)

(3) - Intact steel failure fraction. The B_4C reaction cannot begin until the ratio of the intact steel mass to its initial value falls below this fraction.
(default = 0.9, units = none, equiv = none)

(4) - Reaction threshold temperature. The B_4C temperature must exceed this value or the reaction cannot proceed.
(default = 1500., units = K, equiv = none)

1006 – B_4C Reaction Rate Parameters

These coefficients are used to control the reaction rate of B_4C. The fractional reaction rate (per second) is given by

$$\frac{d(M/M_o)}{dt} = C1006(1)\exp\left(\frac{-C1006(2)}{T}\right)$$

where M_o is the initial mass of the B_4C and M and T are the current mass and temperature of the B_4C, respectively.

(1) - Leading coefficient
(default = 1.662E5, units = s^{-1}, equiv = none)

(2) - Exponent
(default = 2.26472E4, units = K, equiv = none)

1007 – Ring Minimum Flow Area Fractions

These coefficients establish the minimum flow area fractions to be used in the oxidation model to allocate steam and oxygen from the core CVH control volumes to the various rings associated with the control volumes. If the fraction of the CVH volume flow associated with a ring in a control volume falls below the minimum given by the corresponding element of C1007, the ring is assumed to be blocked for oxidation purposes and is assigned that minimum fraction of the oxidizer inventory. The remaining unassigned flow is divided among the unblocked rings (if there are any). If the sum over the NRAD rings in the core exceeds inventory, an error message will be printed and MELGEN/MELCOR execution terminated.

The minimum fractions may be assigned differently for the channel and bypass volumes in a BWR (when those volumes are distinguished in user input).

(IR,1) - Minimum flow area fraction for the channel-side portion of ring IR ($1 \leq$ IR $\leq$ NRAD)
[default=0.0, units=none, equiv=ACHNNL(IR)]

(IR,2) - Minimum flow area fraction for the bypass-side portion of ring IR ($1 \leq$ IR $\leq$ NRAD)
[default=0.0, units=none, equiv=ABYPAS(IR)]

1010 – Material Dissolution Rate Coefficients

These coefficients are used to limit the rate of dissolution of materials by parabolic kinetics. If the coefficients are defined for material j, then the mass fraction of that material in a mixture at the end of the time step cannot exceed

$$XF_j^2 = XI_j^2 + K_j \Delta t$$

where

K_j	=	C1010(1,j) exp(-C1010(2,j)/T)
	=	dissolution constant for material j
XF_j	=	final mass fraction of material j in the mixture
XI_j	=	initial mass fraction of material j in the mixture
Δt	=	time step size
T `	=	temperature (K)

j	solid	C1010(1,j) (unit = none)	C1010(2,j) (units = K)
1	Zr	-1.0(undefined)	0.0 (undefined)
2	ZrO_2	1.47e14	8.01e04
3	UO_2	1.02e15	8.14e04
4	steel	-1.0	0.0
5	steel oxide	-1.0	0.0
6	control poison	-1.0	0.0
7	Inconel	-1.0	0.0

1011 – Eutectic Reaction Temperatures

These coefficients are used to define the temperature at which the rate of eutectic reaction between two contacting solids is sufficiently high to cause significant liquefaction on a time scale of interest. For example, although the Zircaloy-Inconel eutectic reaction may begin as low as 1200 K, the rate of reaction is insignificant until the temperature reaches about 1400 K.

(1) - Zircaloy-Inconel eutectic temperature
(default = 1400.0, units = K, equiv = TZRINC)

(2) - Zircaloy-steel eutectic temperature
(default = 1400.0, units = K, equiv = TZRSS)

(3) - Steel-B4C eutectic temperature
(default = 1520.0, units = K, equiv = TSSB4C)

1020 – Radial Relocation Model Parameters

These parameters control the operation of the routines that relocate both molten material and solid particulate debris from ring to ring.

(1) - Time constant for the relocation of solid material
(default = 360.0 [note that significant changes in the default value have occurred], units = s, equiv = TSPRS)

(2) - Time constant for the relocation of molten material
(default = 60.0 [note that significant changes in the default value have occurred], units = s, equiv = TSPRM)

(3) - Lower head curvature bias for solid material (currently unused)
(default = 0.0, units = none, equiv = FDIPS)

(4) - Lower head curvature bias for molten material (currently unused)
(default = 0.0, units = none, equiv = FDIPM)

(5) - Fraction of cell CVH volume that is available for radial relocation
(default = 1.0, units = none, equiv = CVHFAC)

1021 – Channel-Bypass Relocation Time Constant

This parameter controls the rate of relocation of debris (molten and solid) between the channel and bypass of a BWR after failure of the canisters.

(1) - Time constant for the relocation of debris
(default = 1.0, units = s, equiv = TSPCB)

1030 – dT/dz Model Parameters

These coefficients are associated with the dT/dz model.

(1) - Option switch; if nonzero, the treatment reverts to that used in MELCOR 1.8.3 (and earlier versions) where the possibility of down flow was not considered.
(default = 0.0, units = none, equiv = none.)

(2) - Time constant for averaging flows. The smoothed flows are also used in determining the flow direction if C1030(1) is zero.
(default = 10.0, units = s, equiv = TRLXZ)

(3) - Time constant for relaxing the dT/dz temperatures towards the CVH volume temperature when the dT/dz model is disabled.
(default = 1.0, units = s, equiv = TRLXT)

1101 – Fuel-Cladding Gap Emissivities

These coefficients define the fuel and cladding surface emissivities.

(1) - Fuel surface emissivity
(default = 0.8, units = none, equiv = EMISF)

(2) - Cladding inner surface emissivity
(default = 0.325, units = none, equiv = EMISC)

1131 – Molten Material Holdup Parameters

These coefficients are used to define conditions for which molten material will be held up by an oxide shell. The defaults are currently set so that there is holdup. See the COR Package Reference Manual, Section 3.1, and Section 1.3 of this manual for details on the molten material holdup model.

(1) - Minimum ZrO_2 thickness required to hold up molten Zr.
(default = 0.00001, units = m, equiv = DZXMN)

(2) - Maximum ZrO_2 temperature permitted to hold up molten Zr.
(default = 2400.0, units = K, equiv = TZXMX)

(3) - Minimum steel oxide thickness required to hold up molten steel.
(default = 0.001, units = m, equiv = DSXMN)

(4) - Maximum steel oxide temperature permitted to hold up molten steel.
(default = 1700.0, units = K, equiv = TSXMX)

1132 – Core Component Failure Parameters

These coefficients define the temperatures used in extended failure criteria for fuel after the Zr has melted and candled [by virtue of exceeding the temperature specified by C1131(2)].

In older versions of MELCOR, fuel rods were converted to particulate debris when the remaining thickness of unoxidized Zircaloy in the cladding fell below the value set by DRCLMN on input record COR00008. MELCOR 1.8.4 and later versions allow oxidized rods to continue to stand until the temperature reaches TRDFAI. In MELCOR 1.8.4, the default value was 2800 K, the approximate temperature of the UO_2/ZrO_2 eutectic. While this may be appropriate for new fuel, evidence from Phebus suggests that 2500 K is more appropriate for irradiated fuel. The variable TRDMAX defines the absolute maximum temperature at which rods can stand, regardless of Zircaloy content or the value of TRDFAI; the default value is the approximate melting temperature of UO_2. Refer to Section 1.3 of this manual for additional information.

(1) - Temperature to which oxidized fuel rods can stand in the absence of unoxidized Zr in the cladding.
(default = 2500.0, units = K, equiv = TRDFAI)

(2) - Temperature at which fuel rods will fail, regardless of composition of the cladding.
(default = 3100.0, units = K, equiv = TRDMAX)

1141 – Core Melt Breakthrough Candling Parameters

These coefficients are used to control the candling model when molten material has just been released after holdup by an oxide shell or by a flow blockage (crust). For this case, the quasi-steady assumptions regarding melt generation built into the candling model are not valid, so an alternate time step size (DTBRK below) is used, along with a maximum melt flow rate (GAMBRK), to eliminate dependencies on molten pool mass and time step size. See the COR Package Reference Manual, Section 3.1.3, for more complete details. The default values are currently chosen so that the model will be active only for large molten pools breaching a crust.

(1) - Timestep size used in candling model for molten material releases immediately after breakthrough of an oxide shell or crust.
(default = 1.0, units = s, equiv = DTBRK)

(2) - Maximum melt flow rate per unit width after breakthrough.
(default = 1.0, units = kg/m-s, equiv = GAMBRK)

1151 – Conglomerate Debris Surface Area Coefficients

These coefficients are used in the model that calculates the surface area of conglomerate debris and the portion of the intact component surface area that remains unblocked by the conglomerate debris. These areas are currently used only in the component oxidation models. See the COR Package Reference Manual, Section 3.1.6, for details. The components are, in order, FU, CL, CN, CB, OS, PD, SS, NS, and PB.

(I,1) - Maximum surface area fraction for debris rivulets on component I.
[default = 0.556, units = none, equiv = FA1MAX(I)]

(I,2) - Maximum surface area fraction for voids in debris for component I.
[default = 0.807, units = none, equiv = FA2MAX(I)]

(I,3) - Fraction of interstitial volume corresponding to FA1MAX(I).
[default = 0.143, units = none, equiv = FV1MAX(I)]

(I,4) - Fraction of interstitial volume corresponding to FA2MAX(I).
[default = 0.396, units = none, equiv = FV2MAX(I)]

(I,5) - Minimum surface area fraction for debris for component I.
[default = 0.0, units = none, equiv = FAMIN(I)]

(I,6) - Maximum fraction of intact surface area blocked.
(default = 1.0 for CL, PD, and PB, I=2, 6, and 9, 0.0 otherwise; units = none, equiv = FBMAX)

(I,7) - Surface-to-volume ratio for debris not in interstitial volume.
(default = 100.0, units = 1/m, equiv = SVRX)

1152 – Surface to Volume Ratio for Fluid

This coefficient is used to limit the surface area for heat transfer from COR to CVH when the core is blocked and the fluid volume is very small.

(1) - Maximum surface-to-volume ratio for fluid, defining upper bound on heat transfer area for COR surfaces.
(default = 1000., units = m^{-1}, equiv = SVRFLU)

1200 – Smoothing of Heat Transfer Coefficients

The values of heat transfer coefficients calculated from appropriate correlations for heat transfer between the surfaces of COR components and the surrounding atmosphere and/or pool are averaged with the values from previous timesteps using

$$h_{new} = f_{old}\ h_{old} + (1 - f_{old})\ h_{calc}$$

to reduce numerical fluctuations. Different weightings of old and new are used for the atmosphere and the pool.

(1) - Weight for old heat transfer to atmosphere.
(default = 0.5, units = none, equiv = none)

(2) - Weight for old heat transfer to pool.
(default = 0.9, units = none, equiv = none)

1212 – Laminar Nusselt Numbers

These coefficients give the constant Nusselt number for various types of laminar forced convective flow.

(1) - Nusselt number for fully developed flow in a circular tube with constant heat flux
(default = 4.36, units = none, equiv = none)

(2) - Nusselt number for fully developed flow in a rod bundle
(default = 4.36, units = none, equiv = none)

1213 – Laminar Developing Flow

These coefficients are used to calculate a developing flow factor for laminar flow. The following equation gives the developing flow factor g in terms of the entrance length z, the equivalent diameter D, the Reynolds number Re, the Prandtl number Pr, and the sensitivity coefficients:

$$g = 1.0 + C1213(1)/([z/(D\,\mathrm{Re}\,\mathrm{Pr})] + C1213(2))$$

(1) - (default = 0.00826, units = none, equiv = none)

(2) - (default = 0.00110, units = none, equiv = none)

1214 – Turbulent Forced Convective Flow in Tubes

These coefficients are used to calculate the Nusselt number for forced convective flow in tubes, given by the following equation in terms of the Reynolds number Re and the Prandtl number Pr:

$$Nu = C1214(1)\mathrm{Re}^{C1214(2)}\,\mathrm{Pr}^{C1214(3)}$$

(1) - constant coefficient
(default = 0.023, units = none, equiv = none)

(2) - Reynolds number exponent
(default = 0.8, units = none, equiv = none)

(3) - Prandtl number exponent
(default = 0.4, units = none, equiv = none)

1221 – Laminar Free Convection between Parallel Vertical Surfaces

These coefficients are used to calculate the Nusselt number for laminar free convection between parallel vertical surfaces. The following equation gives the Nusselt number *Nu* in terms of these coefficients and the Rayleigh number *Ra*, the height *L*, and the separation distance *D*:

$$Nu = C1221(1)Ra^{C1221(2)}(L/D)^{C1221(3)}$$

(1) - constant coefficient.
(default = 0.18, units = none, equiv = none)

(2) - Rayleigh number exponent.
(default = 0.25, units = none, equiv = none)

(3) - L/D exponent.
(default = -1./9., units = none, equiv = none)

1222 – Turbulent Free Convection between Parallel Vertical Surfaces

These coefficients are used to calculate the Nusselt number for turbulent free convection between parallel vertical surfaces. The following equation gives the Nusselt number *Nu* in terms of these coefficients and the Rayleigh number *Ra*, the height *L*, and the separation distance *D*:

$$Nu = C1222(1) Ra^{C1222(2)} (L / D)^{C1222(3)}$$

(1) - Constant coefficient.
(default = 0.065, units = none, equiv = none)

(2) - Rayleigh number exponent.
(default = 1./3., units = none, equiv = none)

(3) - L/D exponent.
(default = -1./9., units = none, equiv = none)

1231 – Forced Convective Flow over a Spherical Particle

These coefficients are used to calculate the Nusselt number for forced convective flow over a single spherical particle. The following equation gives the Nusselt number *Nu* in terms of the Reynolds number Re and the Prandtl number *Pr*:

$$Nu = C1231(1) + C1231(2) \mathrm{Re}^{C1231(3)} \mathrm{Pr}^{C1231(4)}$$

(1) - additive constant (Stokes flow limit)
(default = 2.0, units = none, equiv = none)

(2) - constant coefficient
(default = 0.60, units = none, equiv = none)

(3) - Reynolds number exponent
(default = 0.5, units = none, equiv = none)

(4) - Prandtl number exponent
(default = 1./3., units = none, equiv = none)

1232 – Free Convective Flow over a Spherical Particle

These coefficients are used to calculate the Nusselt number for free convective flow over a single spherical particle. The following equation gives the Nusselt number *Nu* in terms of the Grashof number *Gr* and the Prandtl number *Pr*:

$$Nu = C1232(1) + C1232(2)Gr^{C1232(3)}\,\mathrm{Pr}^{C1232(4)}$$

(1) - additive constant (Stokes flow limit)
(default = 2.0, units = none, equiv = none)

(2) - constant coefficient
(default = 0.60, units = none, equiv = none)

(3) - Grashof number exponent
(default = 0.25, units = none, equiv = none)

(4) - Prandtl number exponent
(default = 1./3., units = none, equiv = none)

By default, boiling heat transfer in the the COR package will be calculated using correlations from the HS package (see the HS Reference Manual). If C1241(5) is nonzero, the simplified correlations from the MARCH 2.0 code, specified by sensitivity coefficient arrays C1241 and C1242, will be used instead. In either case, the CHF temperature difference specified by C1241(4) will be used to determine whether debris in the core or lower head is quenched.

1241 – Simplified Nucleate Boiling Curve

If C1241(5) is nonzero, these coefficients are used to calculate a simplified nucleate boiling curve for pool boiling. The following equation gives the heat transfer coefficient h ($W/m^2 - K$) in terms of the pressure *P* (Pa), the temperature difference ΔT (K), and these coefficients:

$$h = C1241(1)P^{C1241(2)}\Delta T^{C1241(3)}, \Delta T < C1241(4)$$

(1) - Constant coefficient.
(default = 34.5, units = W/m^2-K-$Pa^{0.25}$-$K^{1.523}$, equiv = none)

(2) - Pressure exponent.
(default = 0.25, units = none, equiv = none)

(3) - Temperature difference exponent.
(default = 1.523, units = none, equiv = none)

(4) - CHF temperature difference.
(default = 23.4, units = K, equiv = none)

(5) - Option switch, nonzero to specify use of the simplified MARCH 2.0 model rather than correlations from the HS package.
(default = 0.0, units = none, equiv = none)

1242 – Simplified Transition Film Boiling Curve

If C1241(5) is nonzero, these coefficients are used to calculate a simplified transition boiling curve for pool boiling. The following equation gives the heat transfer coefficient h (W/m^2 – K) in terms of the pressure *P* (Pa), the temperature difference ΔT (K), and these coefficients:

$$h = C1242(1) P^{C1242(2)} \Delta T^{C1242(3)}, \Delta T \geq C1241(4)$$

(1) - Constant coefficient.
(default = 1.41E07, units = W/m^2-K-$Pa^{0.25}$-$K^{-2.575}$, equiv = none)

(2) - Pressure exponent.
(default = 0.25, units = none, equiv = none)

(3) - Temperature difference exponent.
(default = -2.575, units = none, equiv = none)

1244 – Debris Dryout Heat Flux Correlation

These coefficients are used to calculate the dryout heat flux for particulate debris beds using the zero-dimensional Lipinski turbulent correlation, given in Section 2.3.7 of the COR Package Reference Manual.

(1) - Leading coefficient
(default = 0.756, units = none, equiv = none)

(2) - Capillary head for water and 0.5 mm particles
(default = 0.089, units = m, equiv = ZCAP)

(3) - Minimum debris porosity allowed
(default = 0.15, units = none, equiv = none)

1245 – Downward-Facing Lower Head Heat Transfer Correlations

These coefficients are used to calculate downward heat transfer from the lower head to water in the reactor cavity. The critical heat flux as a function of the inclination of the surface ($\theta = 0°$ for downward-facing surfaces) is given by

$$q_{CHF} = [C1245(1) + C1245(2) \cdot \theta^{C1245(3)}](\rho_v)^{0.5} h_{lv}[g\sigma(\rho_l - \rho_v)]^{0.25}$$

where ρ_l and ρ_v are the densities of water and steam, respectively, σ is the interfacial surface tension between steam and water, *g* is the acceleration of gravity and h_{lv} is the latent heat of vaporization of water. The minimum heat flux at the beginning of stable film boiling is given by

$$q_{MIN} = [C1245(4) + C1245(5) \cdot \theta^{C1234(6)}](\rho_v)^{0.5} h_{lv}[g\sigma(\rho_l - \rho_v)]^{0.25}$$

and the film-boiling heat transfer coefficient is given by

$$h_{FLM} = f(\theta)k_v[h_{lv}\rho_v g(\rho_l - \rho_v)/(\mu_v K_v \Delta T)]^{1/3}$$

where k_v is the thermal conductivity of steam, μ_v is the viscosity of steam and $\Delta T = T_{SURF} - T_{SAT}$ is the difference between the surface temperature and the saturation temperature and $f(\theta)$ gives the angular dependence. There are two options for calculating $f(\theta)$. If C1245(7)=0., then $f(\theta)$ is given by

$$f(\theta) = C1245(8)(\sin\theta)^{C1245(9)}$$

otherwise, it is given by

$$f(\theta) = C1245(10) + C1245(11) \cdot \theta^{C1245(12)}$$

Details of the model are given in Section 5.1 of the COR Package Reference Manual.

(1) - Additive constant in q_{CHF} correlation
(default = 0.034, units = none, equiv = none)

(2) - Multiplicative constant in q_{CHF} correlation
(default = 0.0037, units = none, equiv = none)

(3) - Exponent of θ in q_{CHF} correlation
(default = 0.656, units = none, equiv = none)

(4) - Additive constant in q_{MIN} correlation
(default = 4.8E-4, units = none, equiv = none)

(5) - Multiplicative constant in q_{MIN} correlation
(default = 8.2E-4, units = none, equiv = none)

(6) - Exponent of θ in q_{MIN} correlation
(default = 0.407, units = none, equiv = none)

(7) - Film-boiling heat transfer coefficient correlation selection switch
(default = 0., units = none, equiv = none)

(8) - Multiplicative constant in default film-boiling correlation
(default = 0.142, units = none, equiv = none)

(9) - Exponent of sin θ dependence in default film-boiling correlation
(default = 0.3333333, units = none, equiv = none)

(10) - Additive constant in optional film-boiling correlation
(default = 0.055, units = none, equiv = none)

(11) - Multiplicative constant in optional film-boiling correlation
(default = 0.016, units = none, equiv = none)

(12) - Exponent of θ in optional film-boiling correlation
(default = 0.5, units = none, equiv = none)

1246 – Heat Transfer Coefficient, Lower Head to Atmosphere

This coefficient defines that heat transfer coefficient between the lower head and the atmosphere when the head is not completely covered by pool.

(1) - Heat transfer coefficient to be used for that part of the lower head that is exposed to the atmosphere.
(default=10.0, units = W/m^2K, equiv = HATCAV)

1250 – Conduction Enhancement for Molten Components

These coefficients are used to enhance heat transfer at high temperatures, where core debris is molten, to capture the qualitative effects of convection in molten pools. This is done by using an enhanced thermal conductivity in the normal model for conduction between pairs of core components. The enhancement factor is given by

$$Factor = \max\left\{1.0, C1250(2)[T_{\max} - C1250(1)]^3\right\}$$

where T_{max} is the greater of the temperatures of the two components involved.

(1) - Temperature above which enhancement is employed.
(default = 3200., units = K, equiv = TKMIN)

(2) - Coefficient in enhancement.
(default = 0.01 units = K^{-1}, equiv = TKFAC)

3.2 Fission and Decay Power Parameters

1301 – Chexal-Layman Fission Power/Liquid Level Correlation

These coefficients define the constants in the Chexal-Layman fission power/liquid level correlation (described in Section 2.6 of the COR Package Reference Manual), given by the equations:

$$QFRAC = C1301(1)(CUNIT1 \cdot H_r)^{C1301(3)}[(P / C1301(6)]^{C1301(2)}(H / H_r)^{C1301(3)}$$

and

$$H = \max(0.0, \{L + C1301(4)[P / C1301(6)]^{C1301(5)}\})$$

where QFRAC is the fraction of full operating power, P is the pressure, L is the height of the downcomer water relative to the top of active fuel, H_r is an arbitrary reference height (selected as 1 m) inserted in the correlation to render it nondimensional in form, and CUNIT1 is a dimensional constant embedded in the code equal to 3.28084 m^{-1}.

(1) - Multiplicative constant
(default = 3.7E-02, units = none, equiv = none)

(2) - Pressure exponent
(default = 0.3, units = none, equiv = none)

(3) - Liquid level exponent
(default = 0.7, units = none, equiv = none)

(4) - Zero power liquid level
(default = 2.4384, units = m, equiv = none)

(5) - Pressure exponent for zero power liquid level
(default = 0.45, units = none, equiv = none)

(6) - Reference pressure
(default = 7.65318E06, units = Pa, equiv = none)

1311 – Material Fission Power Absorption Efficiencies

These coefficients specify the relative absorption efficiencies of fission power by the core materials. Zr and ZrO_2 are lumped together, as is steel with steel oxide, and Inconel associated with clad is not distinguished from Zr. The coefficients are used in conjunction with coefficients in array 1312 to distribute the fraction 1.0-C1312(1) of the fission power that "escapes" the UO_2 fuel component (i.e., gammas), and are applied only to materials in "active" components, as defined by the remainder of sensitivity coefficient array 1312. The default values differ for BWRs and PWRs. Note that if values for PWRs are modified in MELGEN, the output will print BWR values as the "old" values.

(1) - UO_2 efficiency.
[default = 0.735 BWR, or 0.5 PWR, units = none, equiv = FEFF(1)]

(2) - Zr + ZrO_2 efficiency.
[default = 0.4 BWR, or 0.541 PWR, units = none, equiv = FEFF(2)]

(3) - Steel + steel oxide efficiency.
[default = 0.292 BWR, or 0.565 PWR, units = none, equiv = FEFF(3)]

(4) - Control poison efficiency.
[default = 0.263 BWR, or 0.234 PWR, units = none, equiv = FEFF(4)]

1312 – Component Fission Power Absorption Parameters

These coefficients define the fraction of fission power that escapes the fuel component, and determine which of the various COR components (2 through 6) will absorb this "available" fission power, based on the relative absorption efficiencies in array 1311. The fraction of fission power that escapes the fuel component is given by the quantity [1 – POWFAC(1)]. If POWFAC(1) = 1.0, all fission power will be absorbed by the fuel, regardless of the material efficiencies specified in sensitivity coefficient array 1311. The remaining elements of the array, POWFAC(2:9), serve as flags to indicate the participation of the corresponding component. Only components with nonzero values are considered able to absorb fission power. Currently, energy will not be conserved, with messages generated, unless all values are zero or all are nonzero.

(1) - UO_2 fuel initial absorption fraction.
[default = 0.9, units = none, equiv = POWFAC(1)]

(2) - Participation flag for cladding.
[default = 1.0, units = none, equiv = POWFAC(2)]

(3) - Participation flag for canister portion not adjacent to control blade.
[default = 1.0, units = none, equiv = POWFAC(3)]

(4) - Participation flag for canister portion adjacent to control blade.
[default = 1.0, units = none, equiv = POWFAC(4)]

(5) - Participation flag for OS "other structure".
[default = 1.0, units = none, equiv = POWFAC(5)]

(6) - Participation flag for particulate debris.
[default = 1.0, units = none, equiv = POWFAC(6)]

(7) - Participation flag for supporting structure.
[default = 1.0, units = none, equiv = POWFAC(7)]

(8) - Participation flag for nonsupporting structure.
[default = 1.0, units = none, equiv = POWFAC(8)]

(9) - Participation flag for particulate debris in bypass.
[default = 1.0, units = none, equiv = POWFAC(9)]

1321 – Material Absorption Efficiencies for Decay Heat

These coefficients specify the relative absorption efficiencies of decay heat by the core materials. They are used in conjunction with coefficients in array 1322 to distribute the fraction 1.0-C1322(1) of the decay power that "escapes" the UO_2 fuel component (i.e., gammas), and are applied only to materials in "active" components, as defined by the remainder of sensitivity coefficient array 1312. The default values differ for BWRs and PWRs. Note that if values for PWRs are modified in MELGEN, the output will print BWR values as the "old" values. Defaults are based on ORNL report ORNL/NRC/LTR-94/42, which provides derivations and guidance for evaluation of nondefault values.

(1) - UO_2 efficiency.
[default = 0.735 BWR, or 0.5 PWR, units = none, equiv = FDHEFF(1)]

(2) - Zr efficiency.
[default = 0.4 BWR, or 0.541 PWR, units = none, equiv = FDHEFF(2)]

(3) - Steel efficiency.
[default = 0.292 BWR, or 0.565 PWR, units = none, equiv = FDHEFF(3)]

(4) - Control poison efficiency.
[default = 0.263 BWR, or 0.234 PWR, units = none, equiv = FDHEFF(4)]

(5) - ZrO_2 efficiency.
[default = 0.4 BWR, or 0.541 PWR, units = none, equiv = FDHEFF(5)]

(6) - Steel oxide efficiency.
[default = 0.292 BWR, or 0.565 PWR, units = none, equiv = FEFF(6)]

(7) - Inconel efficiency.
[default = 0.4 BWR, or 0.541 PWR, units = none, equiv = FDHEFF(7)]

1322 – Component Decay Power Absorption Parameters

These coefficients define the fraction of decay power that escapes the fuel component, and determine which of the various COR components (2 through 6) will absorb this "available" decay power, based on the relative absorption efficiencies in array 1321. The fraction of decay power that escapes the fuel component is given by the quantity [1 – PWDHFC(1)]. If PWDHFC(1) = 1.0, all decay power will be absorbed by the fuel, regardless of the material efficiencies specified in sensitivity coefficient array 1321. The remaining elements of the array, PWDHFC(2:9), serve as flags to indicate the participation of the corresponding component. Only components with nonzero values are considered able to absorb

decay power. Currently, energy will not be conserved, with messages generated, unless all values are zero or all are nonzero.

(1) - UO_2 fuel initial absorption fraction.
[default =0.5, units = none, equiv = PWDHFC(1)]

(2) - Participation flag for cladding.
[default = 1.0, units = none, equiv = PWDHFC(2)]

(3) - Participation flag for canister portion not adjacent to control blade.
[default = 1.0, units = none, equiv = PWDHFC(3)]

(4) - Participation flag for canister portion adjacent to control blade.
[default = 1.0, units = none, equiv = PWDHFC(4)]

(5) - Participation flag for OS "other structure".
[default = 1.0, units = none, equiv = PWDHFC(5)]

(6) - Participation flag for particulate debris.
[default = 1.0, units = none, equiv = PWDHFC(6)]

(7) - Participation flag for supporting structure.
[default = 1.0, units = none, equiv = PWDHFC(7)]

(8) - Participation flag for nonsupporting structure.
[default = 1.0, units = none, equiv = PWDHFC(8)]

(9) - Participation flag for particulate debris in bypass.
[default = 1.0, units = none, equiv = PWDHFC(9)]

3.3 Numerical Control Parameters

1401 – Time Step Control Parameters

These coefficients are used to control the system time step to prevent instabilities in the interface between the COR package and the CVH package. The interpretation of these coefficients is as follows:

(1) - Maximum ratio by which the time step for the next cycle may be increased.
(default = 1.6, units = none, equiv = DTINC)

(2) - Minimum ratio by which the time step for the next cycle may be decreased.
(default = 0.8, units = none, equiv = DTDEC)

(3) - Minimum value of the ratio between current cycle energy transfer and previous cycle energy transfer before requiring a repeat of the current cycle.
(default = -1.0, units = none, equiv = RATMIN)

(4) - Maximum value of the ratio between current cycle energy transfer and previous cycle energy transfer before requiring a repeat of the current cycle.
(default = 20.0, units = none, equiv = RATMAX)

(5) - Maximum absolute difference from 1.0 of the ratio between current cycle energy transfer and previous cycle energy transfer for any core volume that will allow an increase in the next cycle time step.
(default = 0.5, units = none, equiv = RATINC)

(6) - Minimum absolute difference from 1.0 of the ratio between current cycle energy transfer and previous cycle energy transfer for any volume that will force a decrease in the next cycle time step.
(default = 1.0, units = none, equiv = RATDEC)

1402 – Candling Control Parameter

This coefficient controls the fraction of a material in a component that must be molten before it is considered available to candle. The default value serves only to avoid numerical problems.

(1) - Threshold melt fraction for candling of a material in a component.
(default = 10 times unit roundoff, units = none, equiv = EPSCND)

3.4 Geometric Parameters

1501 – Canister Mass/Surface Area Splits

These coefficients specify the fractions of the input values for canister mass and surface area that are assigned to the two canister components (one adjacent to the control blade, the other not). They also specify the split between inner and outer (bypass and channel) surfaces.

(1) - Fraction of canister mass in component adjacent to control blade.
(default = 0.5, units = none, equiv = FMCB)

(2) - Fraction of canister surface area on inner (fuel-side) surface of component adjacent to the control blade.
(default = 0.5, units = none, equiv = FACBC)

(3) - Fraction of canister surface area on outer (bypass-side) surface of component adjacent to control blade.
(default = 0.5, units = none, equiv = FACBB)

(4) - Fraction of canister surface area on inner (fuel-side) surface of component not adjacent to the control blade.
(default = 0.5, units = none, equiv = FACNC)

(5) - Fraction of canister surface area on outer (bypass-side) surface of component not adjacent to the control blade.
(default = 0.5, units = none, equiv = FACNB)

1502 – Minimum Component Masses

These coefficients specify the minimum component mass below which the masses and energies will be discarded and the minimum component mass below which the component will not be subject to the maximum temperature change criterion. The default value of C1502(2) must be reduced to successfully simulate small-scale experiments.

(1) - Minimum total mass of component.
(default = 1.0E-6, units = kg, equiv = XMCMN1)

(2) - Minimum total mass of component subject to the maximum temperature change criterion for time step control.
(default = 10.0, units = kg, equiv = XMCMN2)

1503 – Core Blockage Parameters

These coefficients specify the geometric parameters affecting core flow blockage.

(1) - Minimum porosity to be used in calculating both the area for heat transfer to fluid and the flow resistance in the flow blockage model.
(default = 1.0E-3, units = none, equiv = PMNCOR)

1504 – Core Cell Volume Consistency Tolerances

These coefficients specify the tolerances on internal consistency in representation of volumes within the COR package database. If either of the limits is exceeded in any core cell, a message will be issued (limited to 100 times each in any execution).

If the discrepancy in total volume exceeds 100 times TOLVT, the calculation will be terminated.

(1) - Permitted relative error in total volume in any cell.
(default = ten times unit roundoff, units = none, equiv = TOLVT)

(2) - Permitted relative error in channel or bypass portion of cell volume in a BWR.
(default = 1.0E-4, units = none, equiv = TOLV1)

3.5 Lower-Head Mechanical Model Parameters

1600 – Model Parameters

These coefficients specify the desired level of modeling detail.

(1) - Switch to choose zero-dimensional (0.0) or one-dimensional (1.0) modeling of the stress and strain distribution in the lower head.
(default = 0.0, units = none, equiv = none)

(2) - Linear expansivity of the lower-head-load-bearing material. (Note, this value is only used if the one-dimensional model has been selected.)
(default = 1.E-5, units = K^{-1}, equiv = none)

(3) - Differential pressure lower limit. The mechanical model will be bypassed whenever the effective differential pressure across the lower head falls below this value. Hence, a large value for this coefficient (e.g., 1.E10) will totally disable the mechanical model.
(default = 1.E3, units = Pa, equiv = none)

1601 – Larson-Miller Creep-Rupture Parameters for Vessel Steel

The Larson-Miller parameter for vessel steel is given by

$$P_{LN} = C1601(1) \cdot \log_{10} \sigma_e + C1601(2)$$

where σ_e is the effective stress in Pa, and the coefficients are material dependent. The default values are typical for reactor vessel carbon steel. The time to failure (rupture) in seconds is given by

$$t_R = 10^{[P/T - C1601(3)]}$$

where T is the temperature in K, and the plastic strain at time $t + \Delta t$ is given by

$$\varepsilon_{pl}(t + \Delta t) = \varepsilon_{pl}(t) + C1601(4) \cdot \Delta t / T_R$$

(1) - Inherently negative multiplicative constant.
(default = -7.294E3, units = none, equiv = none)

(2) - Inherently positive additive constant.
(default = 7.722E4, units = none, equiv = none)

(3) - Additive exponential constant.
(default = 16.44, units = none, equiv = none)

(4) - Total strain assumed to cause failure.
(default = 0.18, units = none, equiv = none)

1602 – Vessel Steel Elastic Modulus Parameters

The elastic modulus of vessel steel is given as a function of temperature, T, by

$$E(T) = C1602(1) \cdot \left(\left\{ [1 + [T / C1602(3)]^{C1602(4)} \right\}^{-1} - \left\{ 1 + [C1602(2) / C1602(3)]^{C1602(4)} \right\}^{-1} \right)$$

(1) - Leading multiplicative constant.
(default = 2.E11, units = Pa, equiv = none)

(2) - Temperature at which elastic modulus vanishes.
(default = 1800.0, units = K, equiv = none)

(3) - Temperature at which elastic modulus is approximately halved.
(default = 900.0, units = K, equiv = none)

(4) - Exponent of scaled temperatures.
(default = 6.0, units = none, equiv = none)

1603 – Vessel Steel Yield Stress Parameters

The yield stress of vessel steel is given as a function of temperature, T, by

$$\sigma_Y(T) = C1603(1) \cdot \left(\left\{ [1 + [T / C1603(3)]^{C1603(4)} \right\}^{-1} - \left\{ 1 + [C1603(2) / C1603(3)]^{C1603(4)} \right\}^{-1} \right)$$

(1) - Leading multiplicative constant.
(default = 4.E8, units = Pa, equiv = none)

(2) - Temperature at which yield stress vanishes.
(default = 1800.0, units = K, equiv = none)

(3) - Temperature at which yield stress is approximately halved.
(default = 900.0, units = K, equiv = none)

(4) - Exponent of scaled temperatures.
(default = 6.0, units = none, equiv = none)

3.6 Support Structure Mechanical Model Parameters

1604 – Larson-Miller Creep-Rupture Parameters for Support Structures

The Larson-Miller parameter for steel in support structures is given by

$$P_{LM} = C1604(1) \cdot \log_{10} \sigma_e + C1604(2)$$

where σ_e is the effective stress in Pa, and the coefficients are material dependent. The default values are typical for stainless steels. The time to failure (rupture) in seconds is given by

$$t_R = 10^{[P/T - C1604(3)]}$$

where T is the temperature in K.

(1) - Inherently negative multiplicative constant.
(default = -7.500E3, units = none, equiv = none)

(2) - Inherently positive additive constant.
(default = 8.100E4, units = none, equiv = none)

(3) - Additive exponential constant.
(default = 16.44, units = none, equiv = none)

1605 – Internal Steel Elastic Modulus Parameters

The elastic modulus of steel in support structures is given as a function of temperature, *T*, by

$$E(T) = C1605(1) \cdot \left(\left\{ [1 + [T / C1605(3)]^{C1605(4)} \right\}^{-1} - \left\{ 1 + [C1605(2) / C1605(3)]^{C1605(4)} \right\}^{-1} \right)$$

(1) - Leading multiplicative constant.
(default = 370.E9, units = Pa, equiv = none)

(2) - Temperature at which elastic modulus vanishes.
(default = 1700., units = K, equiv = none)

(3) - Temperature at which elastic modulus is approximately halved.
(default = 1650., units = K, equiv = none)

(4) - Exponent of scaled temperatures.
(default = 3.0, units = none, equiv = none)

1606 – Internal Steel Yield Stress Parameters

The yield stress of steel in support structures is given as a function of temperature, *T*, by

$$\sigma_Y(T) = C1606(1) \cdot \left(\left\{ [1 + [T / C1606(3)]^{C1606(4)} \right\}^{-1} - \left\{ 1 + [C1606(2) / C1606(3)]^{C1606(4)} \right\}^{-1} \right)$$

(1) - Leading multiplicative constant.
(default = 260.E6, units = Pa, equiv = none)

(2) - Temperature at which yield stress vanishes.
(default = 1700., units = K, equiv = none)

(3) - Temperature at which yield stress is approximately halved.
(default = 800., units = K, equiv = none)

(4) - Exponent of scaled temperatures.
(default = 3.0, units = none, equiv = none)

4. Plot Variables and Control Function Arguments

The plot variables and control function arguments currently included in the COR package are listed below, along with a brief description. Within slashes (/ /) a 'p' indicates a plot variable and a 'c' indicates a control function argument. To reduce the size of the file, variables related to the canister or the bypass region are not written to the plot file for

PWRs. These include properties of particulate debris in the bypass, and the split of volumes between channel and bypass.

Data relating to the OS, SS, and NS components are available only for those components permitted by the value of IOLDOS on MELCOR input record COR00006. In addition, control function arguments involving a component that is not permitted will not be recognized in MELGEN; if one is encountered in MELGEN input, no restart file will be generated.

4.1 Core Mass Variables

COR-MCRP.n	/p/	Total control poison mass in cell n. (units = kg)
COR-MCRP-TOT	/p/	Total control poison in core. (units = kg)
COR-MINC.n	/p/	Total Inconel mass in cell n. (units = kg)
COR-MINC-TOT	/p/	Total Inconel in core. (units = kg)
COR-MSS.n	/p/	Total steel mass in cell n. (units = kg)
COR-MSSOX.n	/p/	Total steel oxide mass in cell n. (units = kg)
COR-MSS-TOT	/p/	Total steel in core. (units = kg)
COR-MSX-TOT	/p/	Total steel oxide in core. (units = kg)
COR-MUO2.n	/p/	Total UO_2 mass in cell n. (units = kg)
COR-MUO2-TOT	/p/	Total UO_2 in core. (units = kg)
COR-MZR.n	/p/	Total Zircaloy mass in cell n. (units = kg)
COR-MZRO2.n	/p/	Total ZrO_2 mass in cell n. (units = kg)
COR-MZR-TOT	/p/	Total Zircaloy in core. (units = kg)
COR-MZX-TOT	/p/	Total ZrO_2 in core. (units = kg)

In the following four variables only, character strings are required for material m and component k, instead of integers. Acceptable strings for material are MUO2, MZR, MSS, MINC, MZRO2, MSSOX, and MCRP. (Interpretation is as in previous variables.) Acceptable strings for component are FU, CL, CN, CB, OS, SS, NS, PB, and PD. (Interpretation is given by the table in Section 1.1.) These four control function arguments are always active, but the corresponding plot variables are active only if IPMV has been set to 1 on MELCOR input record COREDV01.

COR-DC.m.k.n	/pc/	Conglomerate debris mass for material m on component k in cell n. (units = kg)
COR-PB.m.n	/pc/	Particulate debris mass for material m in bypass of cell n. (units = kg)
COR-PD.m.n	/pc/	Particulate debris mass for material m in cell n. (units = kg)
COR-M.m.k.n	/pc/	Total mass (intact plus conglomerate) of material m in component k in cell n. (units = kg)
COR-MUO2-FU.n	/c/	Intact fuel UO_2 mass in cell n. (units = kg)
COR-MZR-CL.n	/c/	Intact cladding Zircaloy mass in cell n. (units = kg)
COR-MZR-CN.n	/c/	Intact canister (including CB) Zircaloy mass in cell n. (units = kg)
COR-MSS-OS.n	/c/	Intact other structure (OS) steel mass in cell n. (units = kg)
COR-MCRP-OS.n	/c/	Intact other structure (OS) control poison mass in cell n. (units = kg)
COR-MZRO2-CL.n	/c/	Intact cladding ZrO_2 mass in cell n. (units = kg)
COR-MZRO2-CN.n	/c/	Intact canister (including CB) ZrO_2 mass in cell n. (units = kg)
COR-MSSOX-OS.n	/c/	Intact other structure steel oxide mass in cell n. (units = kg)

In the following variables, "debris" includes particulate and conglomerate.

COR-MUO2-DB.n	/c/	Total UO_2 debris mass in cell n. (units = kg)
COR-MZR-DB.n	/c/	Total Zircaloy debris mass in cell n. (units = kg)
COR-MSS-DB.n	/c/	Total steel debris mass in cell n. (units = kg)
COR-MZRO2-DB.n	/c/	Total ZrO_2 debris mass in cell n. (units = kg)
COR-MSSOX-DB.n	/c/	Total steel oxide debris mass in cell n. (units = kg)
COR-MCRP-DB.n	/c/	Total control poison debris mass in cell n. (units = kg)

4.2 Core Flow Area and Component Volume Variables

COR-AFLMIN.m.n	/c/	Minimum flow area open between core cells m and n, inclusive (channel and bypass combined for BWR). (units = m2)
COR-VOL-FLU.n	/c/	Volume of fluid ("empty volume") in cell n (total for BWR). (units = m3)
COR-VOL-FLUB.n	/c/	Volume of fluid in bypass of cell n (zero for PWR). (units = m3)
COR-VOL-FLUC.n	/c/	Volume of fluid in channel of cell n (total for PWR). (units = m3)

The following plot variables are active only if IPMV has been set to 1 on MELCOR input record COREDV01.

COR-VOLF-FU.n	/p/	Intact fuel volume fraction in cell n. (units = none)
COR-VOLF-CL.n	/p/	Cladding volume fraction in cell n. (units = none)
COR-VOLF-CN.n	/p/	Canister volume fraction in cell n. (units = none)
COR-VOLF-OS.n	/p/	OS "other structure" volume fraction in cell n. (units = none)
COR-VOLF-SS.n	/p/	Supporting structure volume fraction in cell n. (units = none)
COR-VOLF-NS.n	/p/	Nonsupporting structure volume fraction in cell n. (units = none)
COR-VOLF-PB.n	/p/	Particulate debris volume fraction in bypass of cell n. (units = none)
COR-VOLF-PD.n	/p/	Particulate debris volume fraction in cell n. (units = none)
COR-VOLF-FLB.n	/p/	Fluid volume fraction in cell bypass of cell n. (units = none)
COR-VOLF-FLC.n	/p/	Fluid volume fraction in channel of cell n (BWR only). (units = none)
COR-VOLF-FL.n	/p/	Fluid volume fraction in cell n. (units = none)

4.3 Core Temperature and Melt Fraction Variables

COR-TFU.n	/pc/	Temperature of UO_2 in cell n. (units = K)
COR-TCL.n	/pc/	Temperature of Zircaloy cladding in cell n. (units = K)
COR-TCN.n	/pc/	Temperature of canister (the part not adjacent to the control blade) in cell n. (units = K)
COR-TCB.n	/pc/	Temperature of canister adjacent to control blade. (units = K)
COR-TOS.n	/pc/	Temperature of OS "other structure" in cell n. (units = K)
COR-TSS.n	/pc/	Temperature of supporting structure in cell n.

		(units = K)
COR-TNS.n	/pc/	Temperature of nonsupporting structure in cell n. (units = K)
COR-TPB.n	/pc/	Temperature of particulate debris in bypass cell n. (units = K)
COR-TPD.n	/pc/	Temperature of particulate debris in cell n. (units = K)
COR-TSVC.n	/pc/	Local channel fluid temperature seen by cell n. (units = K)
COR-TSVB.n	/pc/	Local bypass fluid temperature seen by cell n. (units = K)
COR-MLTFR.n.m.k	/c/	Melt fraction of material number m in component number k in cell n. (units = none)

4.4 Core Energy and Heat Transfer Variables

COR-ENERGY-TOT	/p/	Total internal energy in COR package. (units = J)
COR-EFPD-TOT	/p/	Total cumulative fission power and decay heat generated in core. (units = J)
COR-EMWR-TOT	/p/	Total cumulative oxidation heat generated in core. (units = J)
COR-EB4C-TOT	/p/	Total cumulative heat from B_4C reactions in core. (units = J)
COR-ECNV-TOT	/p/	Total cumulative energy transfer to CVH package. (units = J)
COR-EBND-TOT	/p/	Total cumulative energy transfer to HS package. (units = J)
COR-EFPD-RAT	/p/	Total fission power and decay heat generation rate in core. (units = W)
COR-EMWR-RAT	/p/	Total oxidation heat generation rate in core. (units = W)
COR-EB4C-RAT	/p/	Total heat generation rate from B_4C reactions in core. (units = W)
COR-ECNV-RAT	/p/	Total convective heat generation rate in core.

		(units = W)
COR-EBND-RAT	/p/	Total radiative heat transfer rate to boundary heat structures. (units = W)
COR-QCNV.m	/p/	Heat transfer rate to atmosphere in fluid volume m. (units = W)
COR-HTCLH.i	/p/	Heat transfer coefficient from ring i of lower head to water pool. (units = W/m2K)
COR-HTCLH-AVE	/p/	Average heat transfer coefficient from lower head to water pool. (units = W/m2K)
COR-QFLXLH.i	/p/	Heat flux from ring i of lower head to water pool. (units = W/m2)
COR-QFLXLH-AVE	/p/	Average heat flux from lower head to water pool. (units = W/m2)
COR-QTOTLH.i	/p/	Cumulative heat transferred from ring i of lower head to water pool. (units = J)
COR-QTOTLH-TOT	/p/	Total cumulative heat transferred from lower head to water pool. (units = J)

4.5 Core Structural Loading and Damage Variables

COR-SS-STRESS.ijj	/pc/	Maximum component of stress in SS in core cell ijj. (units = Pa)
COR-SS-DAMAGE.ijj	/pc/	Damage fraction (fraction of damage that will produce failure) for SS in core cell ijj. (units = none)
COR-SS-TLEFT.ijj	/pc/	Remaining life for SS in core cell ijj (for unchanged temperature and load).

4.6 Core Oxidation and B_4C Reaction Mass Variables

COR-DMH2-TOT	/p/	Total cumulative hydrogen production in core. (units = kg)
COR-DMCO-TOT	/p/	Total cumulative carbon monoxide production in core. (units = kg)

COR-DMCO2-TOT	/p/	Total cumulative carbon dioxide production in core (available only for MCRP = 'B4C'). (units = kg)
COR-DMCH4-TOT	/p/	Total cumulative methane production in core (available only for MCRP = 'B4C'). (units = kg)

4.7 Variables involving Melting Heat Structures and BH Package

Note that, in all cases, mass and energy transfers from the COR package are defined as positive.

COR-MCTOHS-TOT	/p/	Total mass added to HS by COR. (units = kg)
COR-ECTOHS-TOT	/p/	Total enthalpy of mass added to HS by COR. (units = J)
COR-MCTOBH-TOT	/p/	Total mass added to BH by COR. (units = kg)
COR-ECTOBH-TOT	/p/	Total enthalpy of mass added to BH by COR. (units = J)
COR-RCTOBH-TOT	/p/	Total energy radiated to BH debris by COR. (units = J)

4.8 Core Penetration, Lower Head, Breach and Melt Ejection Variables

COR-TPN.n	/pc/	Temperature of penetration n. (units = K)

In the following three variables, ijj refers to node jj of ring i, where jj=01 is on the outside of the lower head. (Although nodal information on CORLHNnn records is entered from inside to outside, the nodes are actually numbered in the opposite direction.)

COR-TLH.ijj	/pc/	Temperature of vessel lower head node. (units = K)
COR-VSTRAIN.ijj	/p/	Plastic strain in vessel lower head node. (units = dimensionless)
COR-VSTRESS.ijj	/p/	Stress in vessel lower head node. (units = Pa)
COR-ABRCH	/c/	Total flow area of vessel breach. (units = m2)
COR-MEJEC-TOT	/p/	Total debris mass ejected through vessel breach. (units = kg)

4.9 Core Accounting Variables

COR-DT	/p/	COR package time step. (units = s)
COR-NCYCLE	/p/	Total number of COR package subcycles. (units = none)
COR-CPU	/p/	Total CPU usage by run portion of COR package. (units = s)
COR-MASSERR	/p/	Total mass error for COR package. (units = kg)
COR-ENERGYERR	/p/	Total energy error for COR package. (units = J)
COR-REL-ENGY-ERR	/p/	COR relative energy error, defined as COR-ENERGYERR/ COR-ENERGY-TOT (units = dimensionless)
COR-REL-ENGY-ERM	/p/	COR relative energy error, modified to include enthalpy of mass transfers to BH and HS, defined as COR-ENERGYERR/(COR-ENERGY-TOT + debris to BH and CAV) (units = dimensionless)

5. Example Input

5.1 Example MELGEN Input

The following are sample MELGEN input records for the COR package for a 3-ring by 12-level nodalization. It corresponds to the input example presented in previous versions of

this guide, with the substitution of supporting and nonsupporting structures (SS and NS) for undifferentiated "other structure" (OS), and uses CORijjKcmp input records rather than CORijj02 records. Pending improvements to the core structures support model, a small amount of NS is required in level 1 to support the control rod guide tubes in levels 2 through 5. This example does not represent any real reactor system.

```
* GENERAL CORE INPUT
*
*         NRAD   NAXL   NTLP   NCVOL  NLH    NPNTOT
COR00000  3      12     6      3      5      3
*
*         RFUEL    RCLAD    DRGAP    PITCH  DXCAN  DXSS  DZLH
COR00001  .005207  .0061341 .0001143 .016   .00254 .0012 .2254
*
*         IRTYP   MCRP
COR00002  BWR     B4C
*
*         FCNCL   FSSCN   FCELR   FCELA   FLPUP
COR00003  0.25    0.95    0.25    0.25    0.25
*
*         NTPCOR  ICFFIS  ICFGAP
COR00004  101     -51     61
*
*         HFRZFU HFRLIR HFRZSS HFRLIX HFRZSX HFRZCP
COR00005  2000.0 2000.0 2000.0 2000.0 2000.0 2000.0
*
*         IEUMOD
COR00006  1
*
*         MTUOZR MTZXZR MTSXSS MTCPSS FUOZR  FZXZR  FSXSS  FCPSS
COR00007  1      2      2      2      0.2    1.0    1.0    0.0
*
*         HDBPN   HDBLH   TPFAIL  CDISPN
COR00009   500.0   500.0   1273.15 1.0
*
* CELL ELEVATIONS
*         Z       DZ      PORIN   PORDP
CORZ0101  0.0     1.2954  0.0     0.3  * PORIN NOT USED
CORZ0201  1.2954  0.9803  0.0     0.3
CORZ0301  2.2757  0.9803  0.0     0.3
CORZ0401  3.2560  0.9803  0.0     0.3
CORZ0501  4.2363  0.9803  0.0     0.3
CORZ0601  5.2166  0.2777  0.0     0.3
CORZ0701  5.4943  0.635   0.0     0.3
CORZ0801  6.1293  0.635   0.0     0.3
CORZ0901  6.7643  0.635   0.0     0.3
CORZ1001  7.3993  0.635   0.0     0.3
CORZ1101  8.0343  0.635   0.0     0.3
CORZ1201  8.6693  0.635   0.0     0.3
*
* CELL AXIAL BOUNDARY AREAS
```

```
*         ASCELA
CORR0101  5.729
CORR0201  5.729
CORR0301  5.729
*
* OUTER BOUNDARY HEAT STRUCTURES
CORZ0102  10001      * ISUP NOT USED FOR IOLDOS=0
CORZ0202  10002
CORZ0302  10003
CORZ0402  10004
CORZ0502  10005
CORZ0602  10006
CORZ0702  10207
CORZ0802  10208
CORZ0902  10209
CORZ1002  10210
CORZ1102  10211
CORZ1202  10212
*
* UPPER BOUNDARY HEAT STRUCTURES AND LOWER HEAD FAILURE CF'S
CORR0102  10301   52
CORR0202  10302   53
CORR0302  10303   54
*
* AXIAL POWER DENSITY PROFILE
CORZ0703  0.75
CORZ0803  0.90
CORZ0903  1.20
CORZ1003  1.20
CORZ1103  0.90
CORZ1203  0.75
*
* RADIAL POWER DENSITY PROFILE
CORR0103  1.2
CORR0203  0.9
CORR0303  0.75
*
* SS AND NS OPTIONS
*
* TREAT ALL NS IN INPUT AS CONTROL BLADE
*
COR000NS  BLADE   * NOT REQUIRED, SINCE DEFAULT FOR BWR
*
* TREAT ALL SS IN INPUT AS COLUMN, EXCEPT FOR LEVEL 6.
* LEVEL 6 TO BE TREATED AS PLATEB
*
*                 XNUM    RADO    RADI
COR000SS  COLUMN  50.     0.14    0.13
*                 THICK   SPACE   AKMB
CORZ06SS  PLATEB  0.08    0.3     0.15   * AKMB INCREASED FOR HOLES
*
* LOWER PLENUM INPUT
```

```
*
* CRD HOUSING - *** NOTE: ALL MASS INPUT WITH PENETRATION INPUT
*
*         IREFN   ICVHC   ICVHB
COR10101  -1      100     100

COR101KFU 0.0      * EMPTY: EXPLICITLY SPECIFY COMPONENT OF ZERO MASS
*
*         TFU   TCL   TOS   TCN   TCB   TPD   TSS   TNS
COR10103  560.0 560.0 560.0 560.0 560.0 560.0 560.0 560.0
*
*         DHYCL  DHYOS  DHYDP  DHYCNC DHYCNB DHYSS  DHYNS
COR10104  1.0    1.0    0.005  1.0    1.0    1.0    1.0
*
*         ASCELR  AFLOWC  AFLOWB
COR10105  10.99   5.729   0.0
*
*         ASFU    ASCL    ASOS    ASCN    ASSS    ASNS
COR10106  0.0     0.0     0.0     0.0     0.0     0.0
*
COR20101  101     * REFERENCE TO CELL 101 FOR MISSING INPUT
COR20105  15.54
*
COR30101  101     * REFERENCE TO CELL 101 FOR MISSING INPUT
COR30105  21.98
*
* CR GUIDE TUBES (185)
COR10201  -1      100     100
COR102KSS 1750.0
COR10203  560.0 560.0 560.0 560.0 560.0 560.0 560.0 560.0
COR10204  1.0    1.0    0.005  1.0    1.0    1.0    0.3
COR10205  8.3177  5.5039  0.0
COR10206  0.0     0.0     0.0     0.0     106.1   0.0
COR10301  102     * REFERENCE TO CELL 102 FOR MISSING INPUT
COR10401  102     * REFERENCE TO CELL 102 FOR MISSING INPUT
COR10501  102     * REFERENCE TO CELL 102 FOR MISSING INPUT
*
COR20201  102     * REFERENCE TO CELL 102 FOR MISSING INPUT
COR20205  11.763
COR20301  202     * REFERENCE TO CELL 202 FOR MISSING INPUT
COR20401  202     * REFERENCE TO CELL 202 FOR MISSING INPUT
COR20501  202     * REFERENCE TO CELL 202 FOR MISSING INPUT
*
COR30201  102     * REFERENCE TO CELL 102 FOR MISSING INPUT
COR30205  16.6354
COR30301  302     * REFERENCE TO CELL 302 FOR MISSING INPUT
COR30401  302     * REFERENCE TO CELL 302 FOR MISSING INPUT
COR30501  302     * REFERENCE TO CELL 302 FOR MISSING INPUT
*
* LOWER CORE SUPPORT STRUCTURE (FUEL SUPPORT PIECES, CORE PLATE,
*                               AND FUEL ASSEMBLY NOSE PIECES)
COR10601  -1      100     100
```

```
COR106KSS 5000.0
COR10603  560.0 560.0 560.0 560.0 560.0 560.0 560.0 560.0
COR10604  1.0    1.0    0.005  1.0    1.0    0.15   1.0
COR10605  2.356   3.4585  0.0
COR10606  0.0     0.0    0.0     0.0     50.0    0.0
COR20601  106     * REFERENCE TO CELL 106 FOR MISSING INPUT
COR20605  3.332
COR30601  106     * REFERENCE TO CELL 106 FOR MISSING INPUT
COR30605  4.712
*
* CORE INPUT
*
COR10701  -1      101     102
COR107KFU 9360.0
COR107KCL 1968.0
COR107KNS 596.0   99.2
COR107KCN 730.0
COR107KCB 730.0
COR10703  595.0 560.0 560.0 560.0 560.0 560.0 560.0 560.0
COR10704  0.005  1.0    0.005  0.005  0.003  1.0    0.003
COR10705  5.3879  2.65    0.8
COR10706  328.0   399.0   0.0     86.7    0.0     127.0
COR10801  107     * REFERENCE TO CELL 107 FOR MISSING INPUT
COR10803  595.0   560.0   560.0   560.0
COR10901  107     * REFERENCE TO CELL 107 FOR MISSING INPUT
COR10903  595.0   560.0   560.0   560.0
COR11001  107     * REFERENCE TO CELL 107 FOR MISSING INPUT
COR11003  595.0   560.0   560.0   560.0
COR11101  107     * REFERENCE TO CELL 107 FOR MISSING INPUT
COR11103  595.0   560.0   560.0   560.0
COR11201  107     * REFERENCE TO CELL 107 FOR MISSING INPUT
COR11203  595.0   560.0   560.0   560.0
*
COR20701  107     * REFERENCE TO CELL 107 FOR MISSING INPUT
COR20705  7.6196
COR20801  207     * REFERENCE TO CELL 207 FOR MISSING INPUT
COR20901  207     * REFERENCE TO CELL 207 FOR MISSING INPUT
COR21001  207     * REFERENCE TO CELL 207 FOR MISSING INPUT
COR21101  207     * REFERENCE TO CELL 207 FOR MISSING INPUT
COR21201  207     * REFERENCE TO CELL 207 FOR MISSING INPUT
*
COR30701  107     * REFERENCE TO CELL 107 FOR MISSING INPUT
COR30705  10.7758
COR30801  307     * REFERENCE TO CELL 307 FOR MISSING INPUT
COR30901  307     * REFERENCE TO CELL 307 FOR MISSING INPUT
COR31001  307     * REFERENCE TO CELL 307 FOR MISSING INPUT
COR31101  307     * REFERENCE TO CELL 307 FOR MISSING INPUT
COR31201  307     * REFERENCE TO CELL 307 FOR MISSING INPUT
*
* LOWER HEAD INPUT
*
*         IRS  IRE  TLH    RADLH   ICVCAV
```

```
CORLHD01  1    1    560.0  1.350   205  * RADIUS OF RING 1
CORLHD02  2    2    560.0  1.910        * RADIUS OF RING 2
CORLHD03  3    3    560.0  2.800        * RADIUS OF LOWER HEAD
*  BY DEFAULT, THE LOWER HEAD WOULD BE MODELED AS CARBON STEEL WITH
*  NLH=5 EQUALLY SPACED NODES AND A TOTAL THICKNESS OF DZLH=0.2254M
*  THE FOLLOWING RECORDS DEFINE A HEAD WITH 1 INCH OF STAINLESS
*  STEEL INSIDE A CARBON STEEL SHELL, USING UNEQUALLY-SPACED NODES.
CORLHN01  STAINLESS-STEEL  0.0254  CARBON-STEEL  0.0754
CORLHN02  CARBON-STEEL     0.1754  CARBON-STEEL  0.2254
*
* LOWER HEAD PENETRATIONS INPUT
*
* ALL PENETRATIONS ARE CRD HOUSINGS AND STUB TUBES
* GEOMETRIC VALUES ARE ESTIMATES
*
*         IPNREF  IRP     XMPN    TPN     ASPN    AXPN    AFLPN
CORPEN01  -1      1       704.0   560.0   18.3    0.431   1.03
CORPEN02  1       2
CORPEN03  1       3
*
* COR DT/DZ INLET SPEC INPUT
* THIS INPUT IS NO LONGER REQUIRED OR RECOMMENDED.
* SEE DISCUSSION OF CORTIN RECORD
*
```

The following are sample MELGEN input records for the DCH and RN packages to treat the additional reaction products generated when the advanced B_4C reaction model is selected by overriding the default (simple model) selection with sensitivity coefficient 1005. RN classes 17 – 23 have been defined to treat the additional reaction products, and the DCH input assigns zero decay heat to those classes.

```
************************
* DECAY HEAT DEFINITION *
************************
*
DCHREACTOR 'BWR'
*
*          USE ALL DEFAULT RADIONUCLIDE CLASSES
DCHDEFCLS0 ALL
DCHNEM0000  'CI'   1.E-9
DCHNEM0001  0.  0.
DCHNEM0100  'B2'  1.E-9
DCHNEM0101  0.  0.
DCHNEM0200  'B3'   1.E-9
DCHNEM0201  0.  0.
DCHNEM0300  'B4'   1.E-9
DCHNEM0301  0.  0.
DCHNEM0400  'B5'  1.E-9
DCHNEM0401  0.  0.
DCHNEM0500  'B6'   1.E-9
DCHNEM0501  0.  0.
```

```
DCHNEM0600  'B7'   1.E-9
DCHNEM0601  0.  0.
DCHNEM0700  'B8'  1.E-9
DCHNEM0701  0.  0.
DCHCLS0160  'CSI'
DCHCLS0161  'CI'
DCHCLS0170  'H3B3O6'
DCHCLS0171  'B2'
DCHCLS0180  'HBO2'
DCHCLS0181  'B3'
DCHCLS0190  'BH3'
DCHCLS0191  'B4'
DCHCLS0200  'B2H6'
DCHCLS0201  'B5'
DCHCLS0210  'BOH'
DCHCLS0211  'B6'
DCHCLS0220  'B(S)'
DCHCLS0221  'B7'
DCHCLS0230  'C(S)'
DCHCLS0231  'B8'
*
**********************
* RADIONUCLIDE INPUT *
**********************
*
*       ACTIVATE RN1 PACKAGE
RN1000  0
*
*       DEFINE 23 RN CLASSES
*       NUMSEC NUMCMP NUMCLS NCLSW NCLSBX NUMSRA NUMSRV NCLCSI
RN1001  5      1      23     14    13     0      0      16
*
```

5.2 Example MELCOR Input

The following are sample MELCOR input records for the COR package.

```
*         DTMPCR  DTCMIN  NSUBMX
CORDTC01  30.0    0.005   32
*
*         ITEMP IMASS IVOL  IASUR IPMV
COREDV01  1     1     1     0     0
*
*         IRAD  ICND  ICNV  IOXD  IDRP  ITDZ  IB4C  IRDS  IDEJ  ISPR
CORTST01  0     0     0     0     0     0     1     0     1     0
```

6. COR Package Output

The COR package output provides a description of the current state of the reactor core, including any debris. Many two-dimensional arrays dimensioned (NAXL,NRAD) are printed in a matrix format from the top down to aid in visualizing the physical processes modeled in the core.

For a MELGEN run and on the first cycle of a MELCOR restart, all the available information from the COR package is printed, including much of the time-independent data base. By default, only temperatures and masses, along with energy and mass balances and some statistical information, are written for succeeding edit cycles. However, the user may also specify the editing of various geometric variables, such as surface areas or cell flow areas, or may eliminate nearly all the COR package edit information, through use of the edit flags specified on the COREDV01 MELCOR input record.

Special messages are written to the message file at the time of failure for each supporting structure and each lower head penetration, at the beginning and end of the falling debris quench calculation in each ring, and at the beginning of debris ejection to the cavity.

Complete output for a sample problem can be found in the output listing for the demonstration problem distributed with MELCOR.

7. Diagnostics and Error Messages

Diagnostics and error messages generated during MELGEN are concerned with input processing and are generally self-explanatory. If these messages seem obscure or are otherwise unhelpful in isolating an input problem, please contact the MELCOR code development group.

A variety of messages may be generated during the execution phase of MELCOR. Some of these are merely informative, and should not be of much concern unless they occur very frequently during the calculation. Others indicate very serious problems in the calculation and should be referred to the MELCOR code development group. If a calculation aborts (gracefully or not) please save all input, output, plot, and restart files for use by the code developers in resolving the error.

The following list describes in some detail various messages generated during MELCOR execution and the appropriate action to be taken by the user.

<u>Nonfatal Diagnostics:</u>

(1) WARNING FROM COR PACKAGE
ENERGY ERROR IS BECOMING LARGE

The relative energy error has exceeded a preset limit (currently 5.E-5). The magnitude of this error is indicative of its importance in the calculation and should normally be within a factor of 100 of machine roundoff. Any error over 5.E-4 should be reported to the MELCOR code development group.

(2) WARNING FROM COR PACKAGE
MASS ERROR IS BECOMING LARGE

The relative mass error has exceeded a preset limit (currently 5.E-5). The magnitude of this error is indicative of its importance in the calculation and should normally be within a factor of 100 of machine roundoff. Any error over 5.E-4 should be reported to the MELCOR code development group.

(3) WARNING FROM COR PACKAGE
VOLUME ERROR IS BECOMING LARGE

The relative volume error has exceeded a preset limit (currently 5.E-5). The magnitude of this error is indicative of its importance in the calculation and should normally be within a factor of 100 of machine roundoff. Any error over 5.E-4 should be reported to the MELCOR code development group.

(4) WARNING FROM COR PACKAGE
INTERNAL ENERGIES DID NOT CONVERGE IN CELL nnnn, COMPONENT nn
DECOR=x.xxxxEyy,SUMMCP=x.xxxxEyy,TNEW=xxxx.xx,ENEW=x.xxxEyy

Difficulty was encountered in equilibrating the internal energies of the materials within a cell component. The COR package continues the calculation by repeating the subcycle with a smaller time step. Frequent occurrences of this message should be reported to the MELCOR code development group.

(5) TIME STEP CUT IN COR PACKAGE
TOO LARGE AN ENERGY SINK GENERATED IN VOLUME nnn
DELE=x.xxxxEyy, ETOT=x.xxxxEyy

Energy transfer calculated from the control volume fluid to the core materials is greater than the available energy in the volume. The system time step is reduced and the cycle is repeated. Frequent occurrences of this message should be reported to the MELCOR code development group.

(6) TIME STEP CUT IN COR PACKAGE
TOO LARGE A MASS SINK GENERATED IN VOLUME nnn
DELM=x.xxxxEyy, XMASS=x.xxxxEyy

The consumption of steam by metal oxidation calculated by the COR package is greater than the available mass in the volume. The system time step is reduced

and the cycle is repeated. Frequent occurrences of this message should be reported to the MELCOR code development group.

(7) CORRAD – Implied View Factor > 1
s1 IN CELL ijj <-> s2 IN CELL kll

As a result of inappropriate input or change in geometry, some view factor implied by reciprocity ($A_iF_{ij} = A_jF_{ji}$) exceeds unity.

Here, "s" may be any of the surfaces "PELLET", "CLAD", "CAN","CAN-B", "OTH.STR", "PRT.DBR", "CAN.OUT", "CAN-B.O", "RAD.BND", or "AXL.BND", where, "AXL.BND" and "RAD.BND" refer to an unnamed component in one cell that provides an axial or radial boundary for a named component in another. Axial level NAXL+1 and radial ring NRAD+1 refer to the heat structures providing the radiative boundary condition specified by input record CORRii02 or CORZjj02, respectively.

(8) VIEW FACTOR ERROR IN CORVF
SUM OF VIEW FACTORS EXCEEDS UNITY FOR SURFACE s IN CORE CELL ijj

The sum of view factors input or implied for a single surface may exceed unity. This is not a particularly serious problem, because only pairs of surfaces are considered (MELCOR does not use a net enclosure model.)

In neither case 7 nor case 8 will the message be repeated more than 50 times; the last will include a final line

FURTHER MESSAGES SUPPRESSED

If such warnings are seen in MELGEN diagnostics (under conditions of intact geometry), user input should be reexamined and, in most cases, modified.

(9) VOLUME CONSISTENCY WARNING IN CELL ijj at location
Channel volume error = x.xxxEeee (m3)
Bypass volume error = x.xxxEeee (m3)
Net volume error = x.xxxEeee (relative)

Here "at location" indicates the point in the advancement through the time step where the problem was detected. This message normally represents an incursion of channel components into the bypass region of a BWR, or vice versa, by more than the limit set by Sensitivity coefficient C1504(2). It is not a significant cause of concern unless the magnitude is large.

(10) VOLUME CONSISTENCY ERROR IN CELL ijj at location
Net volume error = x.xxxEeee (relative)

Here "at location" indicates the point in the advancement through the time step where the problem was detected. This message is a result of an inconsistency in the internal representation of volumes in the COR package by more than the limit set by Sensitivity coefficient C1504(1). It is indicative of a more severe error than the preceding message.

In neither case 9 nor case 10 will the message be repeated more than 100 times; the last will include a final line

FURTHER MESSAGES SUPPRESSED

Fatal Error Messages:

(1) MATERIALS PROPERTIES ERROR DETECTED IN COR PACKAGE

An error flag was set by one of the materials properties subroutines called by the COR package. This may indicate bad input data for a material property table or an error generated by the COR package. All material property data should be checked by the user, and if the error is not resolved, it should be reported to the MELCOR code development group.

(2) COR PACKAGE TIME STEP IS TOO SMALL

DTC = xxx.xxxxEyy

The subcycling time step used in the COR package has been cut to less than 1.E-5 seconds. Report this error to the MELCOR code development group.

(3) TOO MANY SUBCYCLES OR TOO SMALL A TIME STEP IN COR PACKAGE or SUBCYCLE TIME STEP IN COR PACKAGE IS TOO SMALL

Too many COR package subcycles were generated during a single system cycle, or the subcycle time step was reduced to below the user-specified minimum. User input variables on record CORDTC01 can be adjusted, but if the COR package then consumes an excessive amount of CPU time or if the error message reoccurs, it should be reported to the MELCOR code development group.

(4) ERROR IN CALL TO TPIN FROM CORMEJ

An error flag was set by the Transfer Process package during melt ejection. Transfer Process package input should be checked for consistency with requirements by the COR package (see input record COR00004).

(5) CONVERGENCE FAILURE IN SUBROUTINE CORPAE

Convergence while equilibrating material energies in a cell component could not be obtained even after reducing the subcycle time step to the user-specified minimum. Report this error to the MELCOR code development group.

(6) ERROR IN SUBROUTINE CORUVN

TOTAL MASS IS ZERO IN COMPONENT nn OF CELL nnnn

ATTEMPT TO ADD ENERGY = x.xxxxEyy

An error has been detected during an attempt to transfer energy to or from a cell component that has zero mass. This error should be reported to the MELCOR code development group.

(7) CONTROL FUNCTION ERROR IN SUBROUTINE CORabc

An error flag was set by the Control Function package during a call from subroutine CORabc. The user input for the control function should be checked. If the error cannot be resolved, it should be reported to the MELCOR code development group.

(8) TABULAR FUNCTION ERROR IN SUBROUTINE CORabc

An error flag was set by the Tabular Function package during a call from subroutine CORabc. The user input for the tabular function should be checked. If the error cannot be resolved, it should be reported to the MELCOR code development group.

(9) VOLUME CONSISTENCY ERROR IN CELL ijj at location
Net volume error = x.xxxEeee (relative)
MUST INCREASE VOLT=SC1504(1) TO CONTINUE

Here "at location" indicates the point in the advancement through the time step where the problem was detected. This message is a result of an inconsistency in the internal representation of volumes in the COR package by more than 100 times the limit set by Sensitivity coefficient C1504(1). It is indicative of a severe error, and should be reported to the MELCOR code development group.

(10) ERROR IN SUBROUTINE CORabc

An error was detected in subroutine CORabc. Any errors of this form should be reported to the MELCOR code development group.